"Analysis of functional outcome in Floating knee injury"

Dissertation submitted in
Partial fulfillment of the regulations required for the award of
M.S. DEGREE
In
Orthopaedic Surgery Branch – II

THE TAMILNADU
DR. M.G.R. MEDICAL UNIVERSITY
CHENNAI
APRIL 2013

CERTIFICATE

This is to certify that this dissertation titled ***"Analysis of functional outcome in floating knee injury"*** submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the requirement for the award of M.S Degree Branch - II (Orthopaedic Surgery) is a bonafide work done by ***DR.AMRUTH K.H.***, under my direct guidance and supervision in the Department of Orthopaedic Surgery, Coimbatore Medical College Hospital, Coimbatore during his period of study from May 2010-April 2013.

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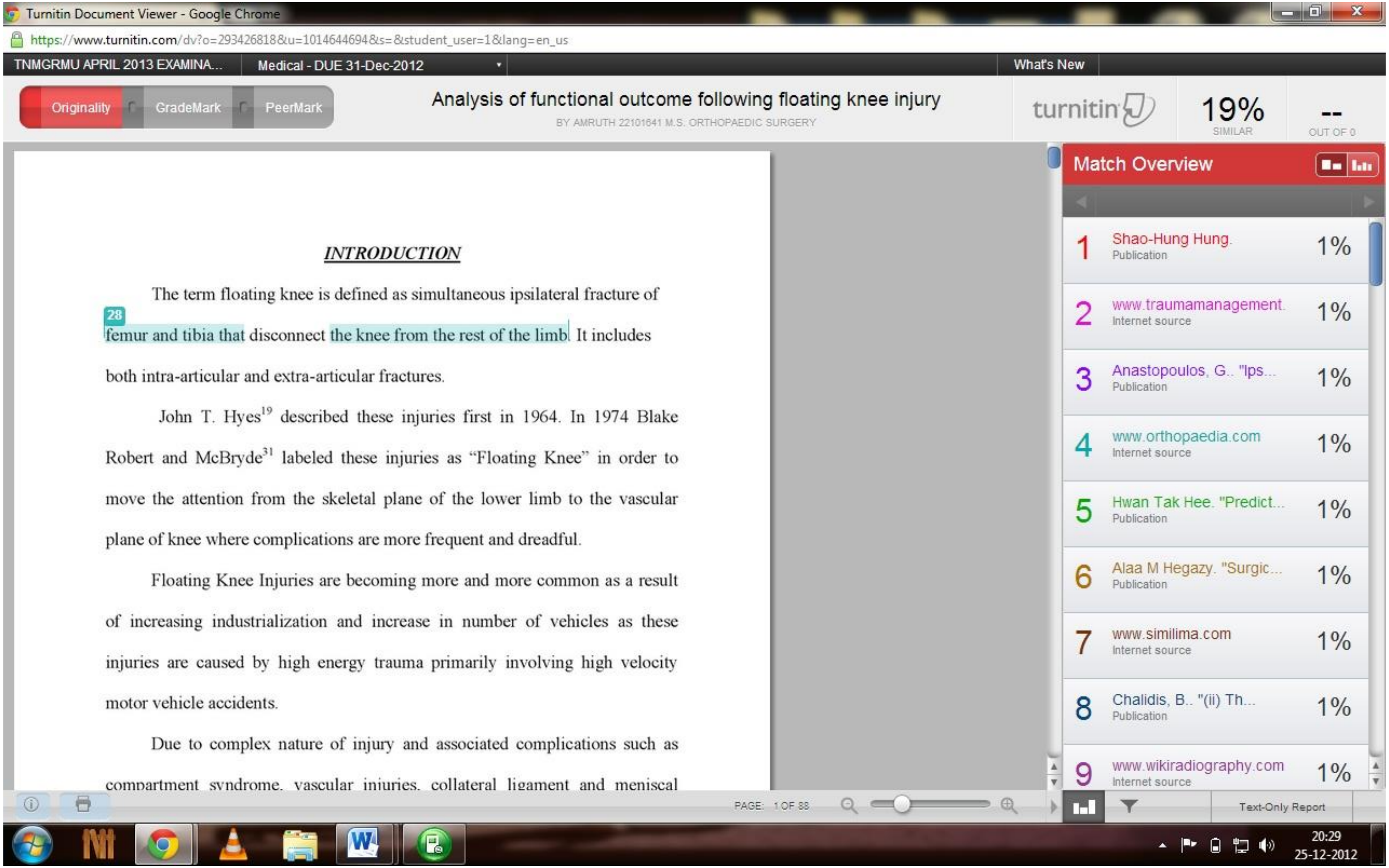
INTRODUCTION The term floating knee is defined as simultaneous ipsilateral fracture of femur and tibia that disconnect the knee from the rest of the limb. It includes both intra-articular and extra-articular fractures. John T. Hyes 19 described these injuries first in 1964. In 1974 Blake Robert and McBryde 31 labeled these injuries as “Floating Knee” in order to move the attention from the skeletal plane of the lower limb to the vascular plane of knee where complications are more frequent and dreadful. Floating Knee Injuries are becoming more and more common as a result of increasing industrialization and increase in number of vehicles as these injuries are caused by high energy trauma...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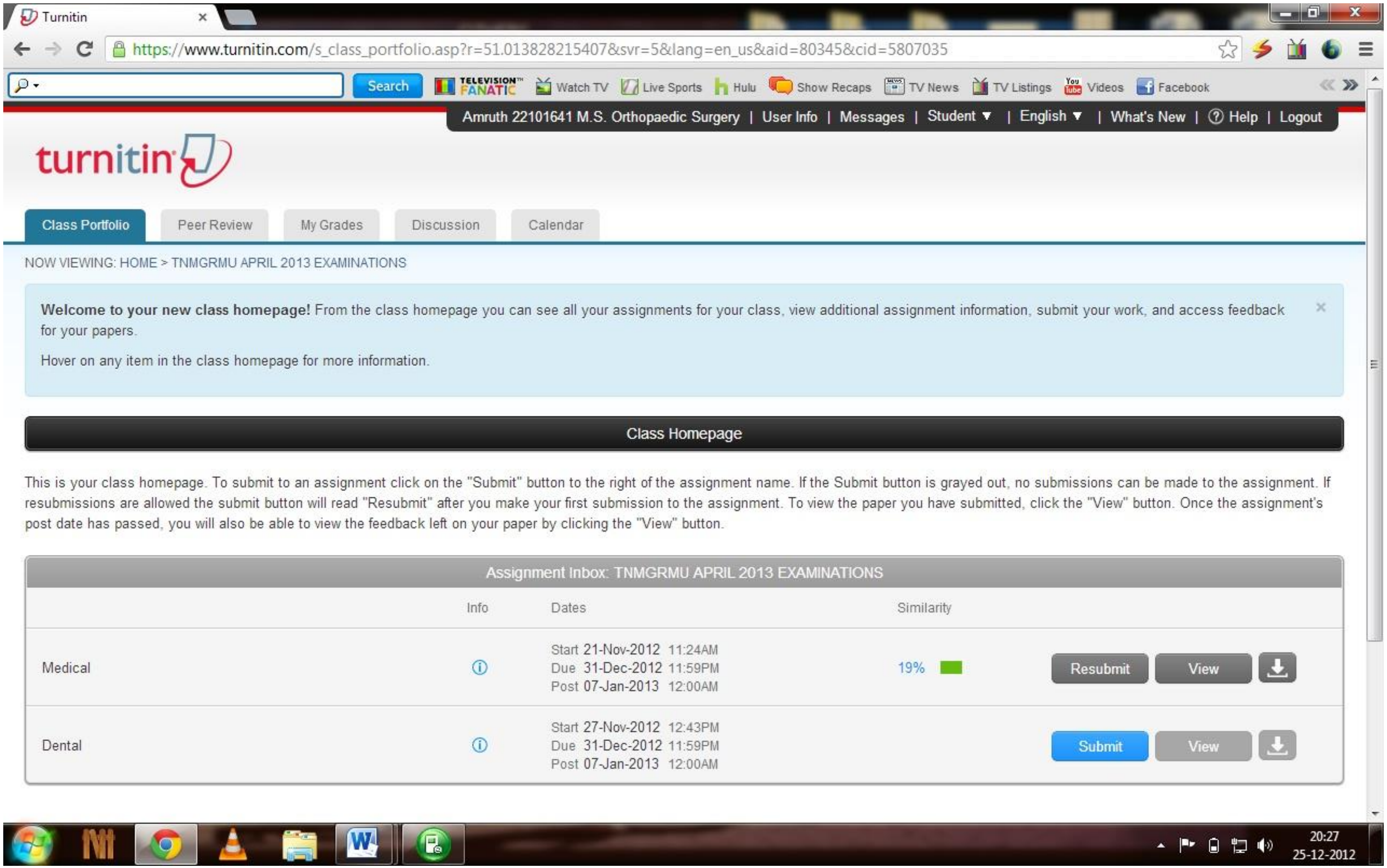
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DECLARATION

I, **Dr. AMRUTH K H** declare that the Dissertation titled ***"Analysis Of Functional Outcome In Floating Knee Injury"*** submitted to the Dr. MGR medical university, Guindy, Chennai is an original work done by me during the academic period from May 2010-April 2013 at the Department of Orthopaedics, Coimbatore Medical College Hospital, Coimbatore, under the guidance and direct supervision of **Dr.S.Vetrivel Chezian D ortho,MS Ortho**, in partial fulfillment of the rules & regulations of the Dr. MGR Medical university for MS Orthopaedics post graduate degree.

All the details of the patients, the materials and methods used are true to the best of my knowledge.

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Dr. AMRUTH K H

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CONTENTS

INTRODUCTION

The term floating knee is defined as simultaneous ipsilateral fracture of femur and tibia that disconnect the knee from the rest of the limb. It includes both intra-articular and extra-articular fractures.

John T. Hyes[19] described these injuries first in 1964. In 1974 Blake Robert and McBryde[31] labeled these injuries as “Floating Knee” in order to move the attention from the skeletal plane of the lower limb to the vascular plane of knee where complications are more frequent and dreadful.

Floating Knee Injuries are becoming more and more common as a result of increasing industrialization and increase in number of vehicles as these injuries are caused by high energy trauma primarily involving high velocity motor vehicle accidents.

Due to complex nature of injury and associated complications such as compartment syndrome, vascular injuries, collateral ligament and meniscal injuries, management of these types of fractures is a challenging therapeutic problem. Most often these kind of ipsilateral fractures are compound and associated with severe damage of soft tissues.

The combined femoral and tibial fractures are frequently accompanied by life threatening head injury, injuries to spinal cord, thoracic and abdominal (Visceral) injuries.

Surgical stabilization of both the femur and tibia fractures, early rehabilitation of the patient produces best clinical outcome. Although treatment planning for each fracture in the extremity should be considered individually to achieve the optimal results, the effect of that decision must be considered in the light of overall injury status of the entire extremity and general condition of the patient.

The results will be better and the complications will be less if the fractures are diaphyseal or extra articular than compared to intra-articular fractures. The main aim of the early internal fixation of both, femur & tibia in floating knee injuries is to obtain union of the fractures in the anatomical position compatible with maximal functional return of the extremity and to reduce the complications such as delayed union, non-union and knee stiffness.

Early papers about floating knee injuries have pointed out the high risk of complications and of permanent disability associated with these fractures (Hayes 1961; Omer, Moll and Bacon 1968; Ratliff 1968; Winston 1972; Gillquist et al 1973; McBryde and Blake 1974).

Blake and McBryde[31] in the year 1975 suggested Classification system for floating knee injuries in adults which is still widely used. Fraser[14] in the year 1978 suggested another classification system for the floating knee injuries in adults.

Similarly Bohn and Durbin and Letts et al[29] suggested a classification system for ipsilateral fractures of femur and tibia in children.

In 1977, Karlstorm and Olerud[25,] in a review of thirty two patients stressed on the importance of rigid fixation of both the fractures. Karlstorm and Olerud also suggested a universal system to assess the functional results following floating knee injuries.

AIM OF THE STUDY

The aim of the study is to analyze the functional outcome in floating knee injury in Coimbatore Medical College Hospital, Coimbatore.

OBJECTIVES OF THE STUDY

- To study the various modalities of management of floating knee injuries.
- To study the various complications associated with floating knee injuries.

REVIEW OF LITERATURE

In 1961, John T. Hyes[19] who first described these injuries suggested applying axial skeletal traction to control the femur displacements and long leg plaster to control tibial fractures. When the femoral fracture is transverse; fixation with an intramedullary nail will simplify the subsequent management of the tibial fracture. This is particularly helpful when tibial fracture is associated with extensive soft tissue injury.

In 1968, Rotliff AHC[35] found that best results in floating knee injuries were obtained with internal fixation of both femur and tibia fractures. He found good results in 11 of 12 cases treated by internal fixation compared with only 3 good results in 11 patients treated conservatively.

In 1968, Omer GE., Moll JH[33] in his paper concluded that femur fractures which are treated with open reduction and internal fixation walked earlier without support and the fracture healed significantly sooner than those treated by conservative methods.

In 1972, Winston ME[47] found that non-operative treatment of floating knee is a safe method producing acceptable end results without dangers of infection, which are present with internal fixation. The most significant factors producing delayed union and nonunion were initial displacement, comminution and soft tissue injuries. In his series, reasonable range of knee movement was obtained in 17 of 24 patients. 14 had no shortening while 9 cases of tibial delayed or non-union and 3 delayed or non-union of femur.

In 1973, Leach RE[28] in his paper concluded "In most of the simple concomitant fractures of ipsilateral femur and tibia I prefer to treat an appropriate femoral fracture with intramedullary nailing and tibial fracture by casting and early weight bearing. I do not feel that internal fixation of the tibia in such fractures will allow the patient significantly shorter hospitalization time, earlier fracture healing or better knee range of movement.

In 1975, McBryde A.M.Jr., Blake Robert[31] found out that in their series 4 of 20 children had delayed union and 6 required secondary osteotomy after healing. In 81 adult patients 63 had received conservative treatment while 17 femoral fractures and 1 tibial fracture had been treated surgically. The group of cases treated conservatively included 21 limbs that required 41 secondary operations. The incidence of healing disturbances in entire series was 37% and in 15 cases necessitated amputation. Permanent disability was found in 60% patient.

In 1977, Karlstrom Goran, Olerud S[25] in a study of 32 cases concluded that if both the tibia and femur fractures are rigidly fixed internally the incidence of complications are low and the duration of hospitalization is lesser. 12 of 14 patients treated with early internal fixation of both fractures resumed their former occupation compared with 4 of 13 patients treated conservatively.

In 1977, Hojer H. Gilliquist S[20] reported in a study of twenty one patients with proper treatment of shock, prophylaxis against fat embolism, treatment of soft tissue and bony injury, death due to hypovolemic shock was eliminated and the rate of fat embolism reduced to 9.5% compared with earlier series. The fractures of tibia were treated with either plaster of Paris or fixed internally as soon as the general condition of the patient allowed. Majority of the cases of femur fractures are treated with intra medullary nailing. In this study the results were better compared with other earlier studies. The fractures healed within fifteen months and the functional outcome was excellent in 89% of the cases.

In 1978, Fraser RD[14] reviewed the record of two hundred and twenty two cases of floating knee and the patients were categorized according to the type and the method of treatment. 35% of the patients required a second surgery for complications such as nonunion, Osteomyelitis, refracture, delayed union and malunion irrespective of the method of treatment. The incidence of Osteomyelitis was found to be 30% in patients where both the fractures are fixed which is almost 3 times more when only 1 fracture was fixed. The incidence of nonunion and delayed fractures which are treated conservatively was found to be 30%. The results were worst in patients where conservative treatment was employed for both tibia and femur fractures.

In 1979, Joseph Schatzker[38] stated that in the injured leg with floating knee syndrome, both the fractures should be internally fixed not only to facilitate the management of shaft fractures but also to permit assessment of the knee, which can be done accurately only when femur and tibia both are stabilized. In these multiple injuries, the knee often suffers major ligament damage that can very easily escape detection if closed methods are adopted.

In 1979, Delee[13] in his study of 15 patients with floating knee injury, traction followed by cast bracing showed that this was an acceptable method of treatment of floating knee. Patients with severe open injuries or comminution of femoral shaft that cannot be rigidly fixed internally are ideal candidates for this method of treatment. The hospitalization time was also less which was 5 weeks.

In 1982, Watson Jones[46] stated about floating knee, when these fractures occur, there is a high risk of complications and often poor results. The results are better if at least one fracture is treated by internal fixation. Conservative treatment of both the fractures is associated with higher complication rate, higher incidence of secondary complications and significantly longer healing time. .

In 1982, Tay, Tong[42] showed in a study of 14 cases that rigid internal fixation of floating knee injuries through shaft of both the bones gave satisfactory functional result when the diaphyseal femur fracture was associated with a tibial condyle fracture. The fixation of femur fracture rigidly and treatment of tibial condyle fracture with traction was found to be more satisfactory. These severely injured patients should be adequately resuscitated initially and associated vascular and knee ligament injuries must be looked for carefully.

In 1983, Haque I[43] reported conservative treatment of floating knee. Severely comminuted open fracture of distal femur and proximal tibia involving knee was managed conservatively. This indicated a trial of conservative management of these fractures before opting for internal fixation.

In 1984, Robert veith, Winquist, Hanson[45] published report of 57 cases of floating knee. 21 patients had life threatening injuries and in 33 cases the fractures were compound. All the femur fractures except one and about half of the fractures of tibia were fixed internally. The average length of hospitalization was 5 weeks. The complications included 1 below knee amputation, 3 deep infections, 4 un-united fractures and fat embolism syndrome in 13% of the patients. At the last follow up examination which was done at an average of 40.5 months after injury the mean range of knee motion was 129^{o}. In 80% of the patients the results were good or excellent. The results were best when both the fractures were treated surgically.

In 1985, Rooser, Hansson[36] reported use of external fixator in floating knee injuries. In 5 patients, Hoffman apparatus was employed. The patients walked early and the fracture healed without any difficulty. He advocated use of external fixator in treatment of tibia fractures and intramedullary nailing for femur fractures. External fixation of femur fracture is indicated if the general condition of the patient is poor or if there is gross comminution of femoral fracture.

In 1987, Boscher Fouque, Le Nay presented a series of 26 ipsilateral fractures of shafts of femur and tibia treated by internal fixation. 13 healed without complication and achieved good function. Six other regained a similar level of mobility after complication had been treated. The early surgical stabilization of such fractures is advocated allowing recognition of simultaneous injuries of knee.

In 1987, Behr JT, Apel DM, Pinzur MS[11] presented 6 cases of floating knee injuries treated with flexible intramedullary nails within 24 hours of injury. There were 1 femoral and 1 tibial nonunion. 4 patients regained full knee movement.

In 1990, Salary Hosking, Annear[41] reported about injuries to knee ligaments in floating knee injury. In a series of 110 patients, 37 patients with 34 ipsilateral femoral and tibial fractures were examined after 3.7 years after injury. Demonstrable knee ligament laxity was present in 18 (5.3%) of these patients while 6 (1.8%) complained of instability.

In 1991, Bohn W.W., Durbin RA reviewed Study of ipsilateral fractures of femur and tibia in children and adolescents in 44 cases. 30 patients (32 limbs) had an average follow up of 5.1 years (range 1-14 years). Of 15 patients who were less than 10 years old, 3 had early complications. The average time to full unsupported weight bearing was 13 weeks and average combined tibial and femoral overgrowth was 1.8 cms. Most of children below 10 years were treated successfully with closed methods. Of the 15 children who were more than 10 years old, 8 had early complication; the average time to full-unsupported weight bearing was 20 weeks and high incidence of knee ligament injuries.

In 1992, Anastopopulous G, Assimakolopous A. Exarchou E[6] showed study of 32 patients of floating knee. The tibial fractures were treated by external fixator, while 29 of 32 femoral fractures were treated by closed intramedullary nailing. The time of hospitalization was from twelve to hundred and five days with a mean of 30 day. The femoral fractures healed in an average of 15.5 weeks. The results were excellent to good in 80% of the cases and acceptable to poor in 19% of the cases according to Karlstrom and Olerud criteria in a follow up time of 19.5 months.

In 1992, Adanson GJ., Wiss DA., Lowry GL., Peters CL[5] studied 34 patients of Type IIA floating knee injuries i.e. fracture extending into knee joint. In this subgroup of floating knee injuries incidence of open fractures was 62% and incidence of vascular injury was 21 %. Only 24% patients had excellent to good results.

In 1996, Gregory P, Dicicco J, Karpik K[16] published study of treatment with nailing femoral fracture retrogradely and nailing tibia with an unreamed nail. In 47 patients with 50 fractures in ipsilateral of femur and tibial shafts without significant articular involvement. 5 femoral fractures (19%) and 14 tibial fractures (54%) were open. Associated injuries were present in 18 patients. Both bones in 14 extremities had healed or were healing uneventfully at final review. 7 tibia and 3 femur had complications. Functional results were good or excellent in 13 of 20 patients (63%) and 15 of 27 extremities (68%).

In 1996, Schiedts D, Mukisi M, Bouger D, Bastaraud H[39] published study of 24 patients floating knee treated from 1987-1992. External fixation was done for all grade III fractures. Intramedullary nailing was always performed after reaming which led to an increase in incidence of fat embolism. Ipsilateral femoral and tibial nailing decreased incidence of malunion, shortening significantly.

In 2000, Hung, Chen, Cheng, Lin[21] presented series of 21 patients of Type IIA floating knee injuries i.e. fracture extending into knee joint. All the patients were treated with early fixation with intramedullary or surface fixation. Functional outcome using Karlstrom-Olerud criteria was excellent in 1 (4.8%), good in 4 (19%), fair in 5 (23.8%), poor in 11(52.4%). Thus overall outcome of Type IIA fractures is poorer than Type I fractures.

In 2000, Yue et al, Churchill R.S.[49] In a comparative study of operative and non-operative treatment of floating knee in children, concluded that operative stabilization was associated with less leg length discrepancy, angular mal-union and secondary procedures than conservative treatment.

In 2001, Gonzalez RO, Castillo EG in retrospective review of 67 patients of ipsilateral femur and tibia. According to their study best results were found in the patients treated with intramedullary nailing of both tibia and femur.

In 2001, Hwan Tak Hee, Ho poh Wong, Yin Low, Myers[22] carried out multivariate study of 98 patients of floating knee injuries treated operatively. They concluded that increasing age, pack years smoked, soft tissue injury and comminuted fractures were associated with delayed full weight bearing.

In 2002, Yokoyama et al[48] in their multivariate study of 68 cases of floating knee injuries found involvement of knee joint, the severity grade of soft tissue injury in the tibia represented significant risk factors of poor outcome of floating knee injuries.

In 2003, Arslan H., Kapukauya A., Kesemenli C.C., Subasi M.. Coban V[26] studied 24 patients floating knee injuries treated with early rigid fixation of both the bones. Using Karlstrom- Olerud criteria results were excellent in 3 patients, good in 9 patients, fair in 5 patients, and poor in 6 patients,

In 2004, Rios J.A.[4] compared floating knee injuries with single incision technique versus traditional anterograde femur fixation. They concluded that the single incision technique is a safe and faster alternative procedure for type I floating Knee Injuries.

In 2007, Rethnam V[1], studied epidemiology, prognostic indicators and outcome following surgical management. They concluded that the associated injuries and the type of fracture (open, intra articular, comminution) are prognostic indicator in the floating knee. Appropriate management of the associated injuries, intra medullary nailing of both the fractures and post-operative rehabilitation are necessary for good final outcome.

In 2007, Hung SH[21] et al conducted a study on outcome following surgical treatment of type II floating knee injuries. They concluded that intra articular knee involvement is the most important predictor of poor functional outcome in type II floating knee injuries.

In 2008, Parekh AA et al[53] in his study on treatment of distal femur and proximal tibia fractures with external fixation followed by planned conversion to internal fixation concluded that the initial treatment of high energy peri-articular knee fractures with bridging external fixator is a safe option which can be later converted to internal fixation. This is preferred in patients who are unsuitable for initial definitive surgery.

In 2009, Rethnam U[54] et al concluded that in floating knee associated injuries were quite frequent. These associated injuries can cause a delay in surgical management and post-operative rehabilitation. Patients with associated knee and vascular injuries had a poor prognosis in assessment of the final outcome. But majority had a good or excellent outcome.

In 2010, Kao FC[55] et al concluded that the complication rates are higher in patients with open fracture, Fraser type IIC fractures, fractures of tibial plateau and distal tibia regardless of the treatment regimen used.

In 2011, Alaa M Hegazy[56] in his study concluded that the associated injuries and type of fracture whether it is open, intra-articular or comminuted are important prognostic factors in a floating knee. The ideal management of these floating knee injuries is intramedullary nailing of both femur and tibia fractures and early rehabilitation of the patient.

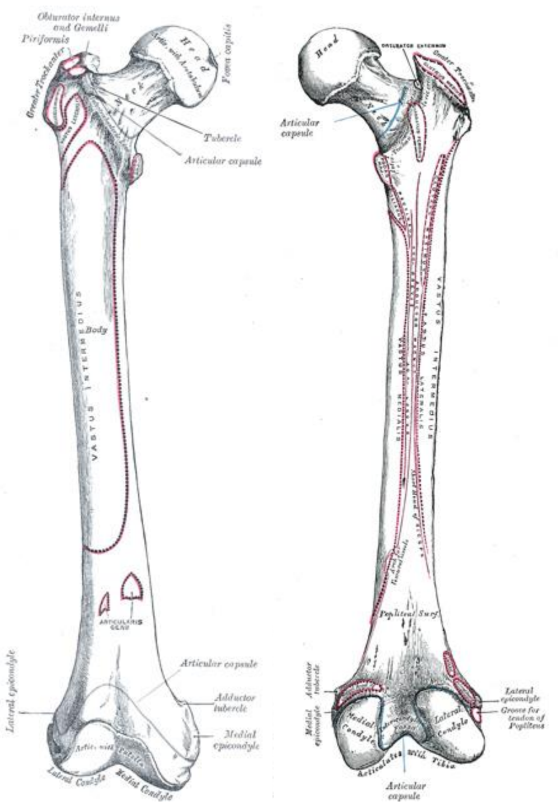
In 2011, Amir C Reis[57] et al emphasized the key role of rehabilitation of patients with floating knee injury and its importance.

ANATOMY

Anatomy of thigh

The femoral diaphysis is the tubular section of the femur that spans the region between the intertrochanteric and supracondylar areas. The important anatomic features of the femoral diaphysis are its shape, vascular supply, surrounding muscles, and neighboring neurovascular structures.

The femur has an anterior bow that varies widely but averages 12 to 15 degrees. Posteriorly, the cortex thickens into a ridge called the linea aspera, which is the origin of the medial and lateral inter-muscular septa.



Right femur - Anterior and posterior surface.

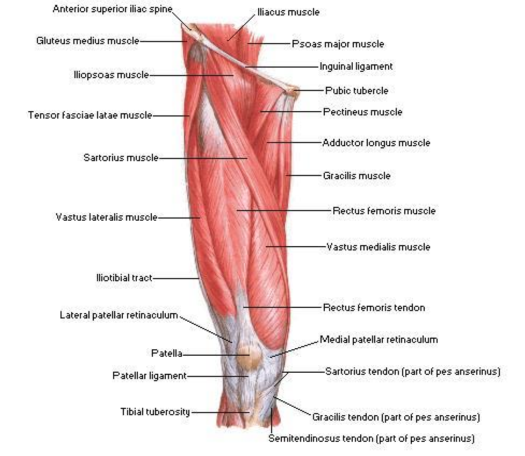
The blood supply is via endosteal and periosteal vessels. Endosteal vessel; originate from nutrient arteries, which enter the proximal third of the femur via foramina in the linea aspera. These nutrient arteries arise from the vessels supplying the surrounding muscles. Following fracture, the periosteal vessel, become the dominant vascular supply.

The muscles of the thigh are separated by the three intramuscular septa medial, lateral, and posterior, forming the three thigh compartments. The anterior (quadriceps) compartment is the largest and contains the quadriceps femoris muscle, iliopsoas muscle, femoral artery and vein, and femoral nerve in the upper part and saphenous nerve in the middle part. The medial (adductor) compartment contains the hip adductor muscles and the profunda femoris artery, which gives off three perforating arteries and is accompanied by a vein. The posterior (hamstring) compartment contains the three knee flexor muscles-biceps femoris, semitendinosus, and semimembranosus, the sciatic nerve, and many branches of the perforating arteries.

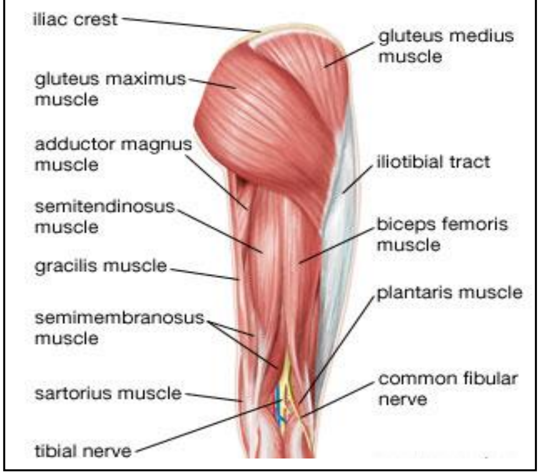
Unopposed action of the muscles results in the displacement of fragment which is predictable depending on the level of the fracture. In fractures proximal to the isthmus of the medullary canal, the proximal fragment is abducted (gluteus), flexed, and externally rotated (iliopsoas). In fractures distal to isthmus, the proximal fragment is in varus (adductors) and angulated posteriorly (quadriceps and gastrocnemius).

The main neurovascular structures of the thigh are the sciatic nerve, femoral nerve, femoral artery, and profunda femoris artery. The sciatic nerve is cushioned from the femur by muscles; therefore it is seldom injured in association with fractures of the femur. The femoral nerve innervates the quadriceps femoris muscle and gives off three branches: the medial and intermediate cutaneous and saphenous nerves. The femoral artery enters the posterior compartment of the thigh from the medial compartment via the adductor hiatus, or Hunter's canal, located just proximal to the distal metaphyseal flare of the femur. The artery is tethered by the inter-muscular septum, and a fracture at this level may injure the vessel. The profunda femoris artery usually gives off three perforating arteries prior to ending proximal to the knee. Some branches of the perforating arteries perforate through the lateral inter-muscular septum, where they terminate in the vastus lateralis. This is of clinical importance since these branches may be cut during the surgical approach to the femur and then retract beneath the lateral inter-muscular septum causing uncontrolled bleeding.

Muscles of Thigh
Anterior View - Superficial Dissection



Muscles of Thigh
Posterior View – Superficial Dissection



Anatomy of Knee joint

The knee joint is the largest joint in the human body. Although it structurally resembles a hinge joint, it actually is a condylar type of synovial joint between two condyles of the femur and tibia. In addition, it also includes a saddle joint between the femur and the patella. It is encompassed by a fibrous capsule that is thin, weak, and incomplete. It is attached to the margins of the femoral and tibial condyles and to the patella and patellar ligament and surrounds the lateral and posterior aspects of the joint. The knee joint consists of consists of the patella-femoral and tibio-femoral joints.

Patello-femoral joint

It is formed by the articular surface of the patella which is adapted to that of the femur. The ‘Odd’ facet contacts the lateral anterior end of the medial femoral condyle in full flexion, when the highest lateral patellar facet contacts the anterior part of the lateral condyle. As the knee extends, the middle patellar facets contact the lower half of the femoral surface. In full extension, only the lowest patellar facets are in contact with the femur. In summary, on flexion the patella-femoral contact point moves proximally. The contact area also broadens to cope with the increasing stress that accompanies rising flexion.

Tibio-femoral joint

Tibial surface

The proximal tibial surface slopes posteriorly and downwards, relative to the long axis of the shaft. The posterior surface, distal to the articular margin, displays a horizontal, rough groove to which the capsular and posterior parts of the medial collateral ligaments are attached. The medial patellar retinaculum is attached to the medial and anterior condylar surfaces which are marked by vascular foramina. The medial articular surface is oval (long axis anteroposterior) and longer than the lateral tibial condyle. Around its anterior, medial, and posterior margins, it is related to the medial meniscus. The Posterior surface is covered by the meniscus, so that overall a concave surface is presented to the medial femoral condyle. The Lateral margin is raised as it reaches the intercondylar region. The lateral condyle overhangs the shaft poster laterally above a small circular facet in articulation with the fibula. The Articular surface is more circular and coapted to its meniscus.

The Intercondylar area (intercondylar eminence) is a rough-surfaced area between the condylar articular surfaces is narrowest centrally where there is an intercondylar eminence, the edges of which project slightly proximally as the lateral and medial intercondylar tubercles. The intercondylar area widens behind and in front of the eminence as the articular surfaces diverge. The anterior intercondylar area is widest. Anteromedially, anterior to the medial articular surface, is a depression in which the anterior horn of the medial meniscus is attached. Behind this a smooth area, receives the anterior cruciate ligament. The eminence, with medial and lateral tubercles, is the narrow central part of the area. The raised tubercles provide some stabilizing influence on the femur.

Posterior horn of the lateral meniscus is attached to the posterior slope of the intercondylar area. Posterior intercondylar area inclines down and backwards behind the posterior horn of the lateral meniscus. Depression behind the base of the medial intercondylar tubercle is for the posterior horn of the medial meniscus. Rest of the area is smooth and provides attachment for the posterior cruciate ligament, spreading back to a ridge for the capsular ligament.

Femoral surface

The Femoral condyles covered with articular cartilage are almost wholly convex. Shapes of their sagittal profiles are somewhat controversial. One view is that they are spiral with a curvature increasing posteriorly (‘a closing helix’), that of the lateral condyle more rapidly. An alternative view is that, the articular surface for contact with the tibia on the medial femoral condyle describes the arcs of two circles. Tibiofemoral congruence is improved by the menisci, which are shaped to produce concavity of the surfaces presented to the femur. The lateral tibiomeniscal surface is deeper. The lateral femoral condyle has a faint groove anteriorly which rests on the peripheral edge of the lateral meniscus in full extension. A similar groove appears on the medial condyle, but does not reach its lateral border, where a narrow strip contacts the medial patellar articular surface in full flexion. These grooves demarcate the femoral, patellar and condylar surfaces. The differences between the shapes of the articulating surfaces correlate with the movements of the joint.

Menisci

The menisci are Crescentic laminae deepening the articulation of the tibial surfaces that receive the femur. They are peripherally attached, the borders are thick and convex; free borders are thin and concave. The peripheral zone is vascularized by capillary loops from the fibrous capsule and synovial membrane, while their inner regions are avascular. Tears are more commonly in the avascular zones and, if treatment is needed, are best resected. Peripheral tears in the vascular zone have the capacity to heal which makes repair a possibility. Outward displacement of the menisci between the femoral condyles is resisted by firm anchorage of the peripheral circumferential fibers to the intercondylar bone at the meniscal horns. The menisci spread load by increasing the congruity of the articulation, give stability by their physical presence and as providers of proprioceptive feedback probably assist lubrication.

The medial meniscus is attached by its anterior horn to the anterior tibial intercondylar area in front of the anterior cruciate ligament. Posterior horn is fixed to the posterior tibial intercondylar area, between the attachments of the lateral meniscus and posterior cruciate ligament. Peripheral border is attached to the fibrous capsule and the deep surface of the medial collateral ligament. Tibial attachment is known as the ‘coronary ligament ’. Collectively, these attachments ensure that the medial meniscus is relatively fixed and moves much less than the lateral meniscus.

The lateral meniscus forms approximately four-fifths of a circle. Anterior horn is attached in front of the intercondylar eminence, posterolateral to the anterior cruciate ligament. Posterior horn is attached behind this eminence, in front of the posterior horn of the medial meniscus. Near its posterior attachment, it commonly sends a posterior meniscofemoral ligament superomedially behind the posterior cruciate ligament to the medial femoral condyle. Anterior meniscofemoral ligament may also connect the posterior horn to the medial femoral condyle anterior to the posterior cruciate ligament. Medially, part of the tendon of popliteus is attached to the lateral meniscus, and so mobility of its posterior horn may be controlled by the meniscofemoral ligaments and popliteus.

Ligaments

Cruciate ligaments

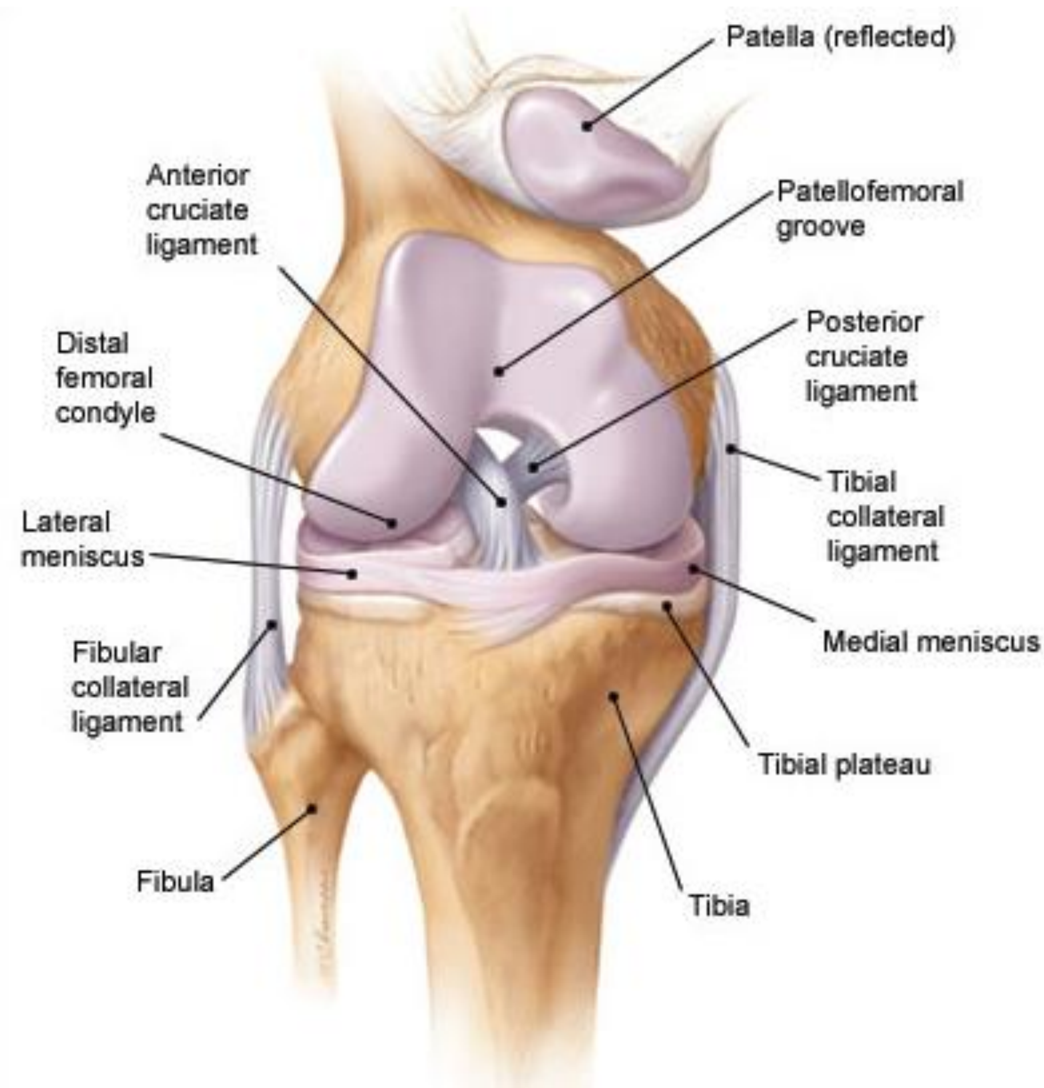
The Cruciate ligaments are very strong and are located a little posterior to the articular center.

Anterior cruciate ligament

They are attached to the anterior intercondylar area of the tibia. It ascends posterolaterally, twisting on itself and fanning out of attach high on the posteromedial aspect of the lateral femoral condyle. They are formed of two or possibly three functional bundles. They are named anteromedial, intermediate and posterolateral according to their tibial attachments.

Posterior cruciate ligament

They are thicker and stronger than the anterior cruciate ligaments. They are attached to the lateral surface of the medial femoral condyle and extend up onto the anterior part of the roof of the intercondylar notch. They pass distally and posteriorly to a fairly compact attachment posteriorly in the intercondylar region and in a depression on the adjacent posterior tibia. They Fan-like structure in which fiber orientation is variable. Anterolateral and posteromedial bundles are named (against convention) according to their femoral attachments.



Anatomy of Knee joint- Anterior view

Innervation of knee joint

The knee joint is innervated by branches from the obturator, femoral, tibial, and common peroneal nerves, the genicular branch of the obturator nerve is the terminal branch of its posterior division. Muscular branches of the femoral nerve, especially to vastus medialis, supply terminal branches to the joint. Genicular branches from the tibial and common peroneal nerves accompany the genicular arteries; those from the tibial nerve run with the medial and middle genicular, while those from the common peroneal nerve run with the lateral genicular and interior tibial recurrent arteries.

Relations and "at risk" structures following floating knee injury

- Anteriorly are the tendon of quadriceps femoris, the patellar tendon, tendinous expansions from vastus medialis and lateralis and the patellar retinacula.
- Posteromedial is Sartorius and the tendon of gracilis which lies along its posterior border, both descending across the joint.
- Posterolaterally the biceps tendon and the common peroneal nerve which lies medial to it are in contact with the capsule , separating it from popliteus
- Posteriorly the popliteal artery and associated lymph nodes lie on the oblique popliteal ligament; the popliteal vein is posteromedial or medial, and the tibial nerve is posterior to both.
- Nerve and vessels are overlapped by both heads of gastrocnemius and laterally by plantaris.
- Gastrocnemius contacts the capsules either side of the vessel. Semimembranosus les between the capsule and semitendinosus, medial to the medial head of gastrocnemius.

Factors maintaining stability

Patello-femoral joint

Alignment of the femoral and tibial shafts is such that the pull of the quadriceps on the patella imparts a force on the patella that is directed both superiorly and laterally. Static bony factors that counter this tendency to move laterally are the congruity of the patellofemoral joint and the buttressing effect of the larger lateral part of the trochlear groove. If the patella is small or resides too high above the trochlea or if the trochlear groove is too shallow, then instability may result. Static ligamentous factors are the medial patellofemoral ligament and medial retinaculum. Vastus medialis obliqus, contains transverse fibers these pull the patella medially, which counters the tendency to lateral movements.

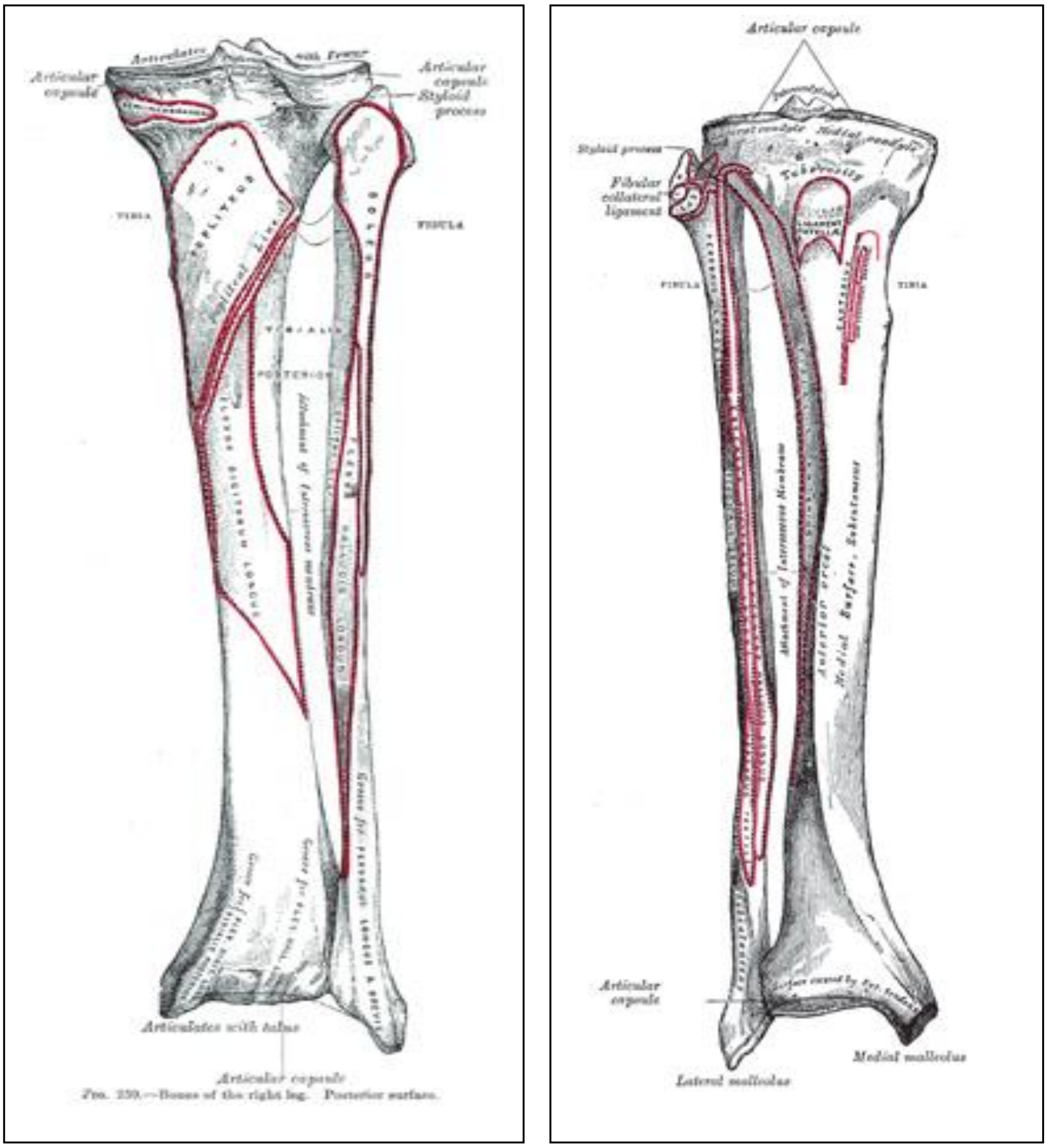
Tibiofemoral joint

Tibiofemoral joint surfaces are inherently unstable, especially laterally. Medially some stability is afforded by the relatively concave tibial surface and the relatively fixed posterior horn of the medial meniscus. Taking a somewhat ‘two-dimensional’ view, the medial and lateral collateral ligaments may be considered as resistors of valgus and varus force on the knee respectively, and the anterior and posterior cruciate ligaments as resistors of anterior and posterior tibial translation respectively. Stresses are rarely applied orthogonal planes and so a combination of forces, especially rotational, is involved. The ‘posterolateral corner’ which resists tibial external rotation consists of the popliteofibular, fabellofibular, arcuate, lateral collateral ligaments and iliotibial band, together with popliteus, the lateral head of gastrocnemius and biceps femoris. The ‘posteromedial corner ‘which resists tibial rotation, consist of the posterior oblique portion of the superficial medial collateral ligaments, the capsule and semimembranosus. Since stresses are often a combination of forces plus rotation, structures usually operate together rather than in isolation.

Anatomy of leg

The anatomy of the leg makes tibia susceptible to fractures. The Entire medial border is subcutaneous and is covered only by skin and subcutaneous tissues. It also makes a tempting target for the enthusiastic surgeon, as the surgical approach to the tibia is simple.

The anterior tibial border in the diaphyseal region of tibia is very dense and extends from tibial tuberosity prominence of tibia lends itself very readily to pin fixation due to a lack of muscles, tendons traversing the anteromedial portion.



Right Tibia and fibula- Anterior and Posterior surface

Tibia is surrounded by muscular envelope and is divided compartments by unyielding deep fascia of the leg.

1. Anterior compartment:

It contains the tibial anterior, extensor digitorum longus, extensor hallucis longus peroneus tertius muscles. This anterior compartment also contains the anterior tibial artery and deep peroneal nerve. The tendons are close to the tibia and the fracture in this area may cause callus formation that comparatively restrict gliding of these tendons.

2. Lateral Compartment:

Lateral compartment contains the muscles peroneus longus and peroneus brevis and they protect the fibular shaft except near the ankle. So isolated fractures of the fibula owing to direct trauma is uncommon, the superficial peroneal nerve in between the peronei and the extensor digitorum longus in the inter-muscular septum, thus the nerve is rarely involved in fracture of the fibular shaft. It is at risk in fractures at fibular neck.

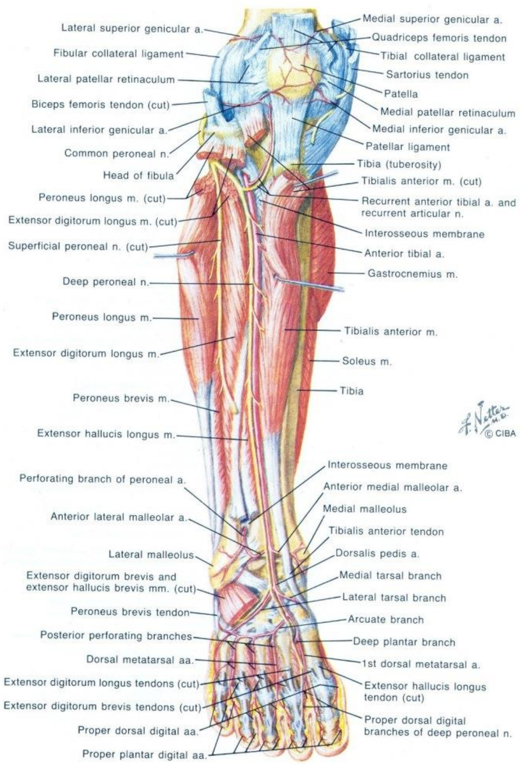
3. Posterior Compartment:

It is further divided into a superficial and a deep compartment.

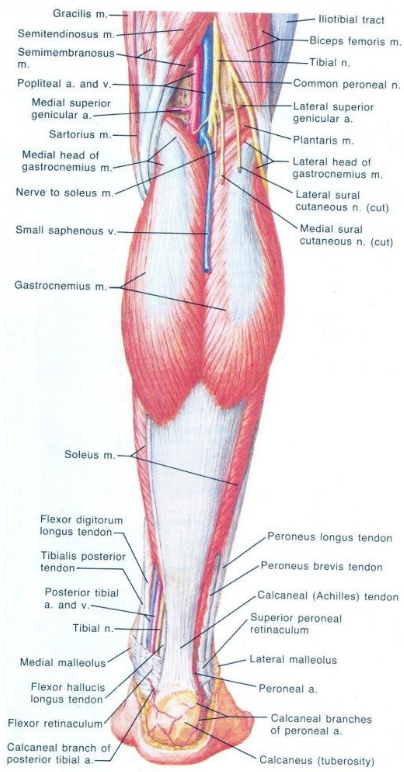
The muscles of this compartment are soleus, gastrocnemius, popliteus, tibialis posterior, flexor hallucis longus and flexor digitorum Longus. The posterior tibial nerve, the posterior tibial artery and its large branch peroneal artery also run in the posterior compartment.

Tibial fracture in the upper third is complicated by the compartment syndrome. This may occur more commonly in the anterolateral compartment and also the posterior compartment. The superficial posterior compartment contains the gastrocnemius, soleus muscle serving as a source for local muscle flaps, which helps in covering the soft tissue defects in the proximal and middle third of tibia.

The posterior tibial artery is usually well protected. It is the major arterial supply after a severe open fracture and is a potential source for anastomosis with the free flaps for soft tissue reconstruction of the leg.



Muscle of Leg (Deep Dissection) – Anterior View



Muscle of Leg (Superficial Dissection) – Posterior View

CLASSIFICATION

1. **Mc Bryde A. Jr and Blake Robert[31]**

Type I or True floating Knee:

Ipsilateral Fracture shaft Femur and Tibia

Type II or Variants of Floating Knee:

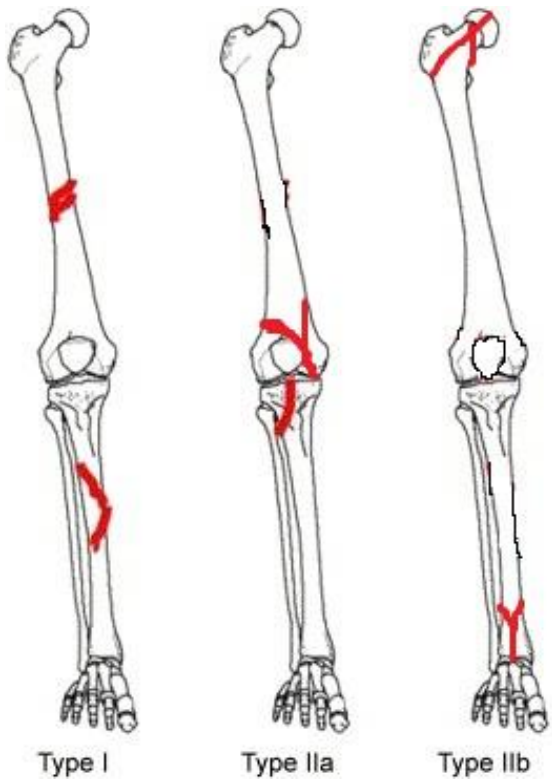
Intra articular extension of fractures

Type IIA:

Femoral, Tibial or both fractures extending into knee joint

Type IIB

Fracture extension into hip or ankle joint.



2. **Fraser classification of floating knee injuries**[14]

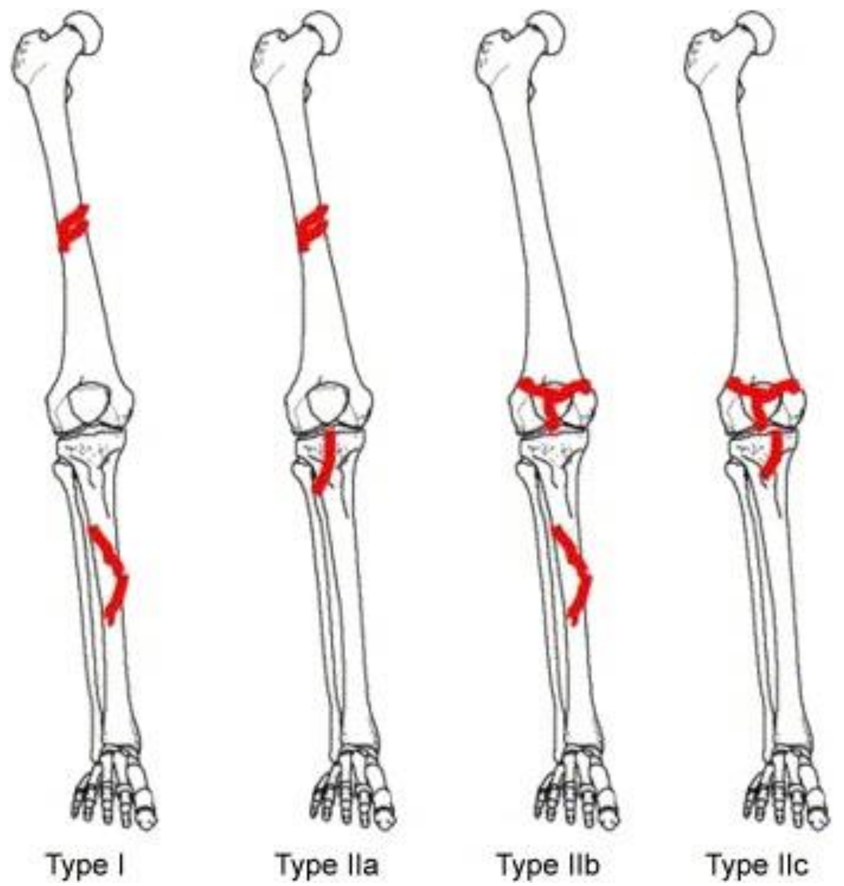
Type I involves extra articular fractures of both femur and tibia

Type II is subdivided into 3 groups, as follows:

Type IIa involves femoral shaft and tibial plateau fractures.

Type IIb includes fractures of distal femur and the shaft of tibia.

Type IIc indicates fractures of the distal femur and tibial plateau.



3. **Letts et al classification in children**[29]

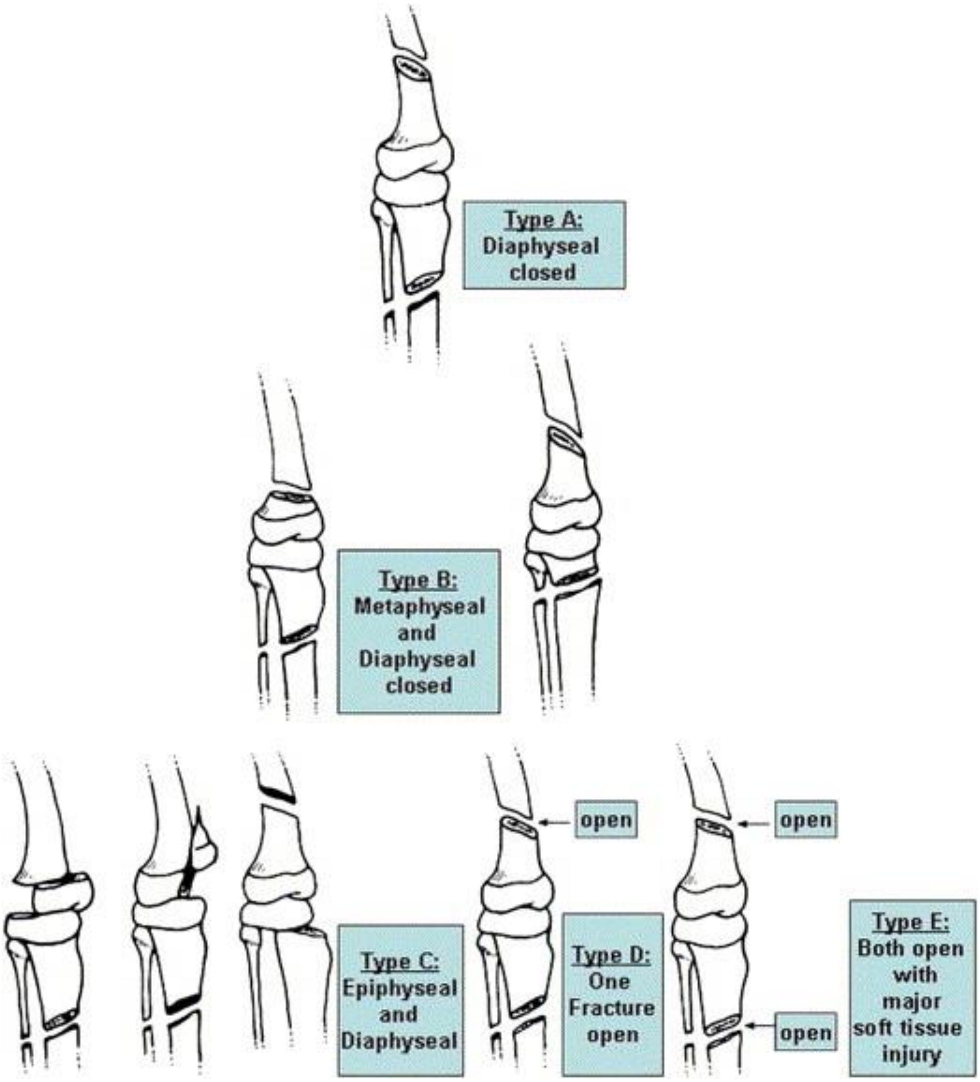
Type A – Both are closed Diaphyseal fractures

Type B- One fracture is diaphyseal, one is metaphyseal and both are closed

Type C- One fracture is diaphyseal and the other is an epiphyseal displacement

Type D- One fracture is open with a major soft tissue injury

Type E- Both fractures are open with major soft tissue injury



Gustilo Anderson's classification for open fractures[17]

Open fractures are classified into three major grades. They are classified according to the mechanism of injury, the degree of soft tissue damage, the configuration of the fracture, and the level of contamination.

Grade I: Clean skin opening of <1 cm, usually from inside to outside; minimal muscle contusion; simple transverse or short oblique fractures.

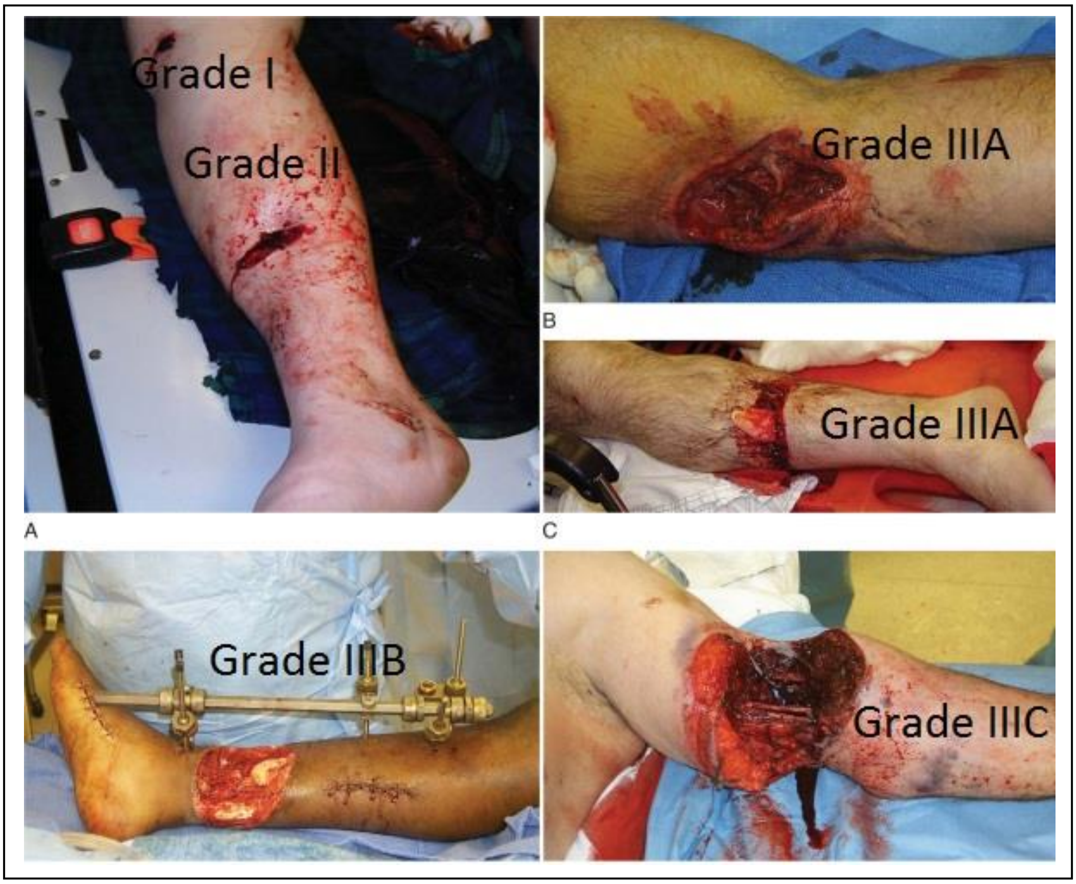
Grade II: Laceration >1 cm long, with extensive soft tissue damage; minimal to moderate crushing component; simple transverse or short oblique fractures with minimal comminution.

Grade III: Extensive soft tissue damage, including muscles, skin, and neurovascular structures; often a high-energy injury with a severe crushing component.

IIIA: Extensive soft tissue laceration, adequate bone coverage; segmental fractures, gunshot injuries, minimal periosteal stripping.

IIIB: Extensive soft tissue injury with periosteal stripping and bone exposure requiring soft tissue flap closure; usually associated with massive contamination.

IIIC: Vascular injury requiring repair.



Gustilo Anderson's classification for open fractures

BIOMECHANICS

The strength of adult bone is about 1/10th that of steel. The tensile strength of tibia is 20 % less than compressive strength. The dominant quality of bone is brittleness; bone behaves more like glass than rubber. When bone is deformed only 2 % of is length, it breaks.

Bone fractures as a result of mechanical overload. The fracture interrupts the structural integrity and stiffness of bone. The morphology of fracture depends upon the type of load exerted and upon the energy released. The degree of fragmentation depends upon the energy stored prior to the process of fracturing. Thus wedge fractures and multi fragmentary fractures are associated with high-energy release.

PATHOPHYSIOLOGY OF LEG INJURY

Every fracture leads to complex injuries involving bone and surrounding soft tissue. Immediately after the fracture and during the repair phase, we see local circulatory disturbances and manifestation of local inflammation as well as pain and reflex immobilization. These three factors circulatory disturbances, inflammation and pain results in dysfunction of joint and muscle leading to so called fracture disease (Lucas-Championniere 1907).

Fracture disease is caused by two main pathogenic factors; pain and lack of physiological challenge to bone muscle complex by movement and mechanical load. In lower limb, this means lack of weight bearing. Fracture disease is therefore a clinical state manifested by chronic edema, soft tissue atrophy and patchy osteoporosis. Edema, as such, induces inter-muscular fibrosis and muscular atrophy. These fibrotic processes cause muscles to develop unphysiological adhesions to bone and fascia leading to stiffness of adjacent joints. .

These sequellae, if fully developed, are very often not completely corrected by long term physiotherapy and lead to partial or complete disability. The rate of disability was 35% following tibial fractures and 70% following femoral fractures. Thus permanent impairment of function is more often due to the fracture disease than defective bone healing or mal-alignment. As most part of tibia is subcutaneous, the open fractures of tibia are common which emphasizes the early recognition of soft tissue injury. The skin trauma may vary from inside out puncture wound to massive skin flap loss. Even if the initial force involves only epidermis and part of dermis avulsed flap may suffer from venous congestion, arterial insufficiency or combination of both. If there is no actual skin loss, healing by secondary intention or contracture is possible. If there is skin loss but bone in not exposed, skin grafting is better option. With exposed bone, local or free fasciocutaneous or myofascial flap is treatment of choice for soft tissue repair.

Blood supply of tibia is derived from the nutrient artery, a branch of posterior tibial artery and periosteal artery derived from anterior tibial artery. After injury the intramedullary vascular pattern is disrupted and periosteal blood vessels increase their contribution. MacNab and De Hass found that the periosteal vessels were especially important in distal third tibial fractures but found no difference in intramedullary blood supply between proximal and distal region. Nonunion in distal third tibia appears to be high due to abnormal stress, torque and shear forces in this area where blood supply is temporarily impaired. Open fracture add to the risk of infection and delayed union.

In case of bone loss, although bone is separated from periosteum, fragmented and even contaminated it is important space filler. If skin cover is available, it can be replaced by bone graft. Secondary bone grafting is treatment of choice in case of tibial fractures with bone loss where infection is under control.

The revascularization of soft tissue is of prime importance in early stage of healing to provide stabilizing callus, which will allow progressive uneventful healing process. Histologically it shows persistence of cartilage in the most peripheral position of callus bridging the gap. Unless there is new bone formation from surrounding tissue it is not possible to re-mould the system.

MATERIALS AND METHODS

The study was done in the department of Orthopedics at Coimbatore medical college hospital, Coimbatore from June 2010 to December 2012 which includes 25 patients with 25 floating knee injuries. This is a prospective study.

Inclusion Criteria:

Patients having ipsilateral fracture Shaft of femur and tibia i.e., McBryde & Black Type I and also ipsilateral fracture femur & tibia with extension into knee joint that is McBryde & Blake Type II A were included into this study.

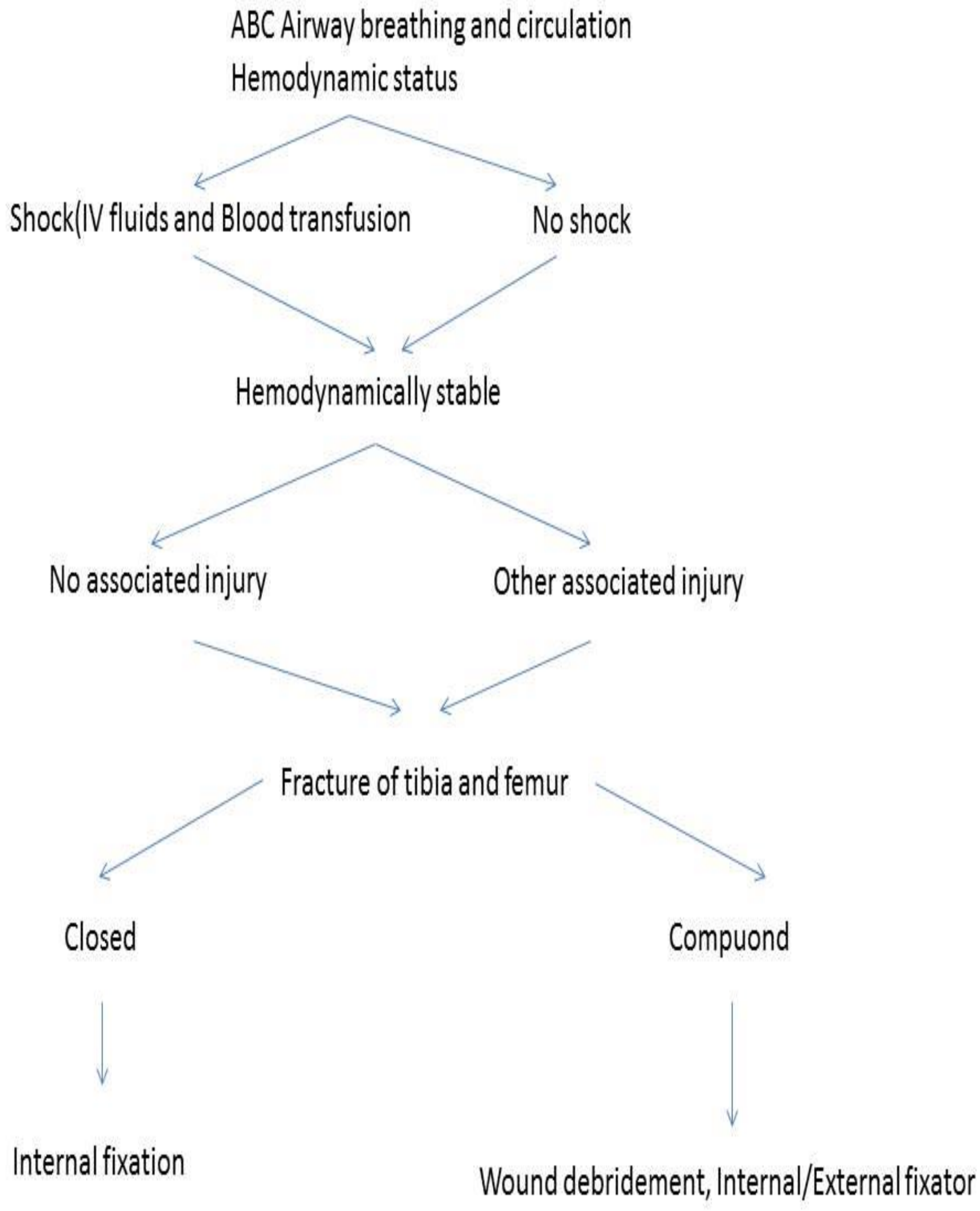
Exclusion Criteria:

Ipsilateral fracture of femur and tibia with extension into the hip and ankle joints and deaths were excluded from the study. Patients who lost to follow up or follow up of less than 4 months were also excluded from the study.

All the patients were victims of high velocity road traffic accidents. Majority of the patients were in the age group of 20-40 years ranging from 16-71 years (mean age 43.5 years).

Right side was involved in 18 of the total 25 floating knee injuries and 24 out of 25 patients were males. 10 cases of tibial fractures were compound as compared to 5 femoral fractures. In 5 cases both the fractures were compound.

There were 13 Type I and 12 Type II A floating knees.



PROTOCOL ON ARRIVAL

On arrival, patients were resuscitated according to ATLS protocol (maintenance of airway with cervical spine control, breathing and circulation). General condition of the patient was assessed with regard to hypovolemia, associated orthopedic or other systemic injuries. Any systemic injury if present was given priority in treatment.

Fracture femur and Tibia were immobilized with Thomas Splint. All patients received analgesics in the form of I.M injection and antibiotics intravenously. In case of compound fractures, immediate debridement and external fixator was applied under anesthesia. When wound was clean cut and not contaminated, primary closure was done after proper debridement. When wound size was large with skin loss, secondary closure, skin grafting or local flaps were done.

Routine investigations were done for all patients. X-rays were taken in two planes – Antero posterior and lateral view.

Pre-operative preparation of Patients:

- Patients were kept NPO for 6-8 hours before surgery
- I.V. Fluids were given as per the need
- I.V. Antibiotics were given to all the patients pre and perioperatively.
- Adequate amount of compatible blood if needed was arranged.

- Preparation of whole extremity, private parts and back was done.
- Written and informed consent was taken.

Intramedullary interlocking nailing was done wherever possible. Anatomical reduction was achieved for intra articular fractures and fixed with plates and screws. Patients were operated under Spinal / General Anesthesia.

SURGICAL TECHNIQUE

Tibia Nailing:

Patient was placed in supine position over the operating table. The injured leg is positioned with knee flexed 90^o to relax the gastro soleus muscle. The uninjured leg is placed in abduction and neutral rotation. The table is adjusted to a comfortable operating height.

Skin incision made from center of the inferior pole of patella to the tibial tuberosity about 5 cm long. The patellar tendon is split in its middle to reach the proximal part of tibial tuberosity. Entry portal was made slightly distal to the tibial plateau with the help of tibial awl. Ball tip guide wire of 3 mm diameter x 1150 mm length passed into medullary canal of proximal fragment. Fracture reduction was done either by open or closed means and the guide wire adjusted to pass into the distal fragment up to about 1 cm. above the ankle joint.

Medullary canal was reamed with reamers, started from 8 mm and increased by 1 mm increments. The medullary canal was reamed 1 mm more than the diameter of isthmus. The nail was introduced as far as possible manually into the medullary canal with the help of the mounted insertion instruments. Insertion was aided by gentle blows with the hammer. The nail was inserted until it is slightly counter sunk in the bone. Routinely we prefer distal locking carried out first, using the tibial jig. The insertion handle was used to locate the holes for proximal locking bolts. Wound closed in layers.

TIBIA NAILING INSTRUMENTS AND IMPLANTS

Femur Nailing:

Patient is placed in the lateral position on the operating table. The skin incision is made centering the fracture site .The tensor fascia lata is incised and the fracture site opened through lateral inter-muscular septum.

The fracture ends are freshened cleared of soft tissues and the proximal and distal fragments are reamed successively starting from 7 mm reamer and increased by 1 mm increments. Pyriformis fossa opened with the reamer and appropriate skin incision made over the trochanter. Guide wire is passed retrogradely from the fracture site and brought out through the proximal incision. The proximal femur reamed with the proximal reamer. The appropriate sized femur nail mounted on the jig is passed over the guide wire, fracture reduced under vision and the nail advanced into the distal fragment. Distal locking is done with the jig followed by proximal locking. Fracture reduction confirmed again and wound closed in layers over a suction drain.

FEMUR NAILING INSTRUMENTS AND IMPLANTS

Condylar Buttress Plating for supra condylar fracture femur :

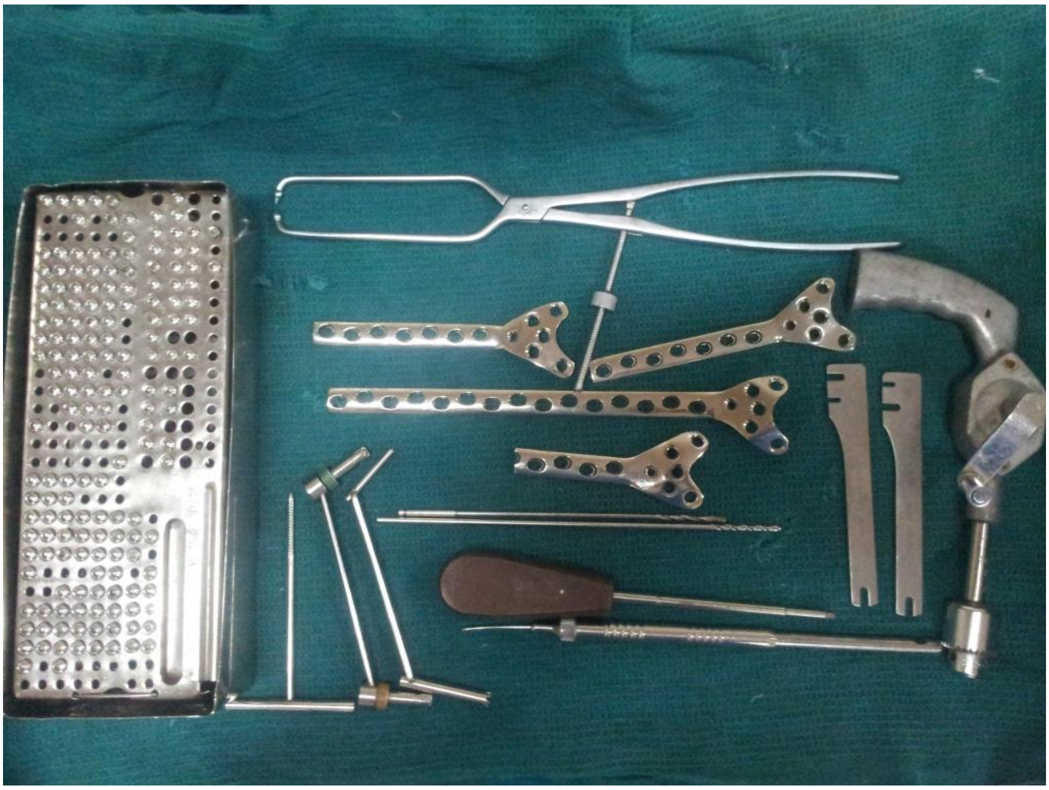
The patient was placed supine on the operating table with sand bag under the ipsilateral hip - semi decubitus position.

Lateral Skin incision was made, parallel to the shaft of femur, beginning at the Gerdy's Tubercle and extending proximally far enough to permit application of a condylar buttress plate with at least four holes above the most proximal fracture line.

Longitudinal incision made through the fascia lata and extended distally into the iliotibial band. Distal part of the incision was extended through the lateral joint capsule and synovium avoiding the injury to the meniscus. Superior lateral geniculate artery were ligated or cauterized if necessary.

Vastus Lateralis was elevated anteriorly to reach the distal 3rd of femur. Minimal amount of soft tissue was stripped necessary for reduction of articular surface and application of the buttress plate.

The femoral condyles were reduced with point reduction bone clamp and congruity of articular surface was visualized directly. Reduction was stabilized temporarily with K-wires. Inter fragmentary cancellous screws were used to approximate the articular surface of distal femur. Condylar buttress plate was applied on the lateral aspect of femur and fixed with screws. Wound closed in layers with suction drain.



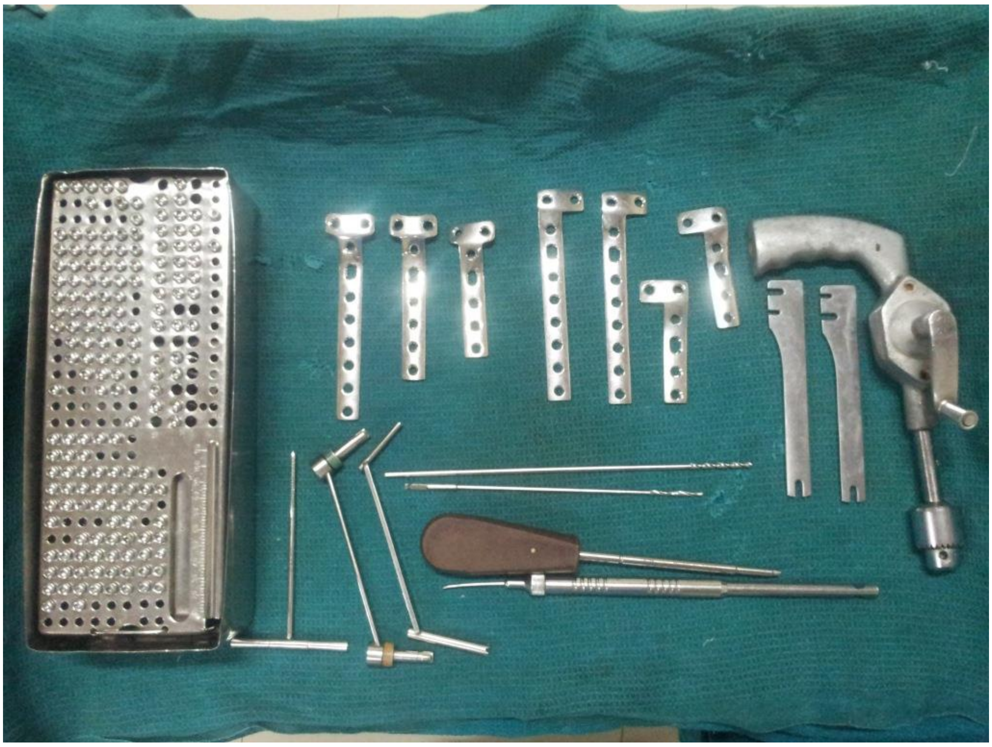
CONDYLAR BUTTRESS PLATING INSTRUMENTS AND IMPLANTS

Open/ Closed reduction and fixation of Tibial plateau fractures :

Patient was placed in supine position with sand bag under the ipsilateral hip – semi decubitus position. Tibial plateau were exposed through a curved incision whose upper part starts laterally halfway between the patella and the tibial plateau, which then curves downward to run straight just lateral to the anterior crest of the tibia. If both plateaus are to be approached simultaneously, a long straight longitudinal midline incision was used.

To expose the longitudinal fracture of the lateral condyle, origin of the extensor muscles was stripped from the anterolateral aspect of the condyle. Depressed articular fragments if any was elevated with periosteal elevator. Elevated and reduced fragments were fixed temporarily with multiple small kirschner wires.

Contoured L or T– Buttress plate was applied to the anterolateral tibial condyle, and secured to the condyle with appropriate cancellous screws of sufficient length to engage the opposite cortex. Cortical screws were used to attach the plate to the shaft of the tibia. Wound closed in layers with suction drain.



TIBIAL PLATEAU FRACTURE PLATING INSTRUMENTS AND IMPLANTS

Dynamic condylar screw fixation for fracture of distal femur:

The patient was placed supine on the operating table with sand bag under the ipsilateral hip - semi decubitus position.

Lateral Skin incision was made, parallel to the shaft of femur, beginning at the Gerdy's Tubercle and extending proximally far enough to permit application of the DCS plate with at least four holes above the most proximal fracture line.

Longitudinal incision made through the fascia lata and extended distally into the iliotibial band. Distal part of the incision was extended through the lateral joint capsule and synovium avoiding the injury to the meniscus. Superior lateral geniculate artery were ligated or cauterized if necessary.

Vastus Lateralis was elevated anteriorly to reach the distal 3rd of femur. Minimal amount of soft tissue was stripped necessary for reduction of articular surface and application of the DCS plate.

The femoral condyles were reduced with point reduction bone clamp and congruity of articular surface was visualized directly.

Under C arm control, one guide wire is passed lateral to medial along the tibio-femoral joint line. A second guide wire is passed over the anterior surface of the knee to indicate the plane of the patello-femoral joint. The ideal position of the DCS is shown by the third guide wire which is inserted parallel to both the K wires. The guide wire for the DCS is positioned at 2 cm proximal to the distal end of femur. On the lateral view, the distal femur is divided into thirds and the DCS entry site is located at the junction of the anterior and middle thirds.

The tip of the guide wire should just engage the medial cortex, and so will appear short of the medial condylar cortex on the AP intensifier image.

Next, the direct measuring device is slid over the guide wire and guide-wire insertion depth is determined and, thereby, the length of the DCS required.

After assembling the DCS triple reamer and setting the reamer to the correct depth, the hole is reamed for the DCS over the guide wire.

After tapping over the guide wire the DCS is inserted so that its outer end is still visible 2-3 mm outside the lateral cortex of the distal femur. Tapping is avoided in osteoporotic bone.

In order for the plate barrel to slide over the screw, the T-handle should be parallel, on the lateral view, to the long axis of the distal fragment.

The impactor is used to bring the plate down to the bone, with the barrel sliding over the screw shank. The compression screw is utilized to couple the screw to the plate. Additionally, the compression screw will provide additional compression across the intra articular split.

A cancellous screw is inserted into the most distal screw hole of the plate to prevent rotation of the distal femoral articular block around the axis of the DCS.

The metaphyseal component of the fracture is reduced and the DCS plate connected to the shaft with 4.5mm cortical screws. Articular congruity ensured again.

Wound lavage given and closed in layers over a suction drain.

DCS INSTRUMENTS AND IMPLANTS FOR FRACTURE OF DISTAL FEMUR

External fixator for compound fractures:

The patient is placed in supine position in the operating table. Thorough debridement of the wound was done. The fracture ends are irrigated with copious amount of normal saline, all debris and contaminated material are removed fracture ends are freshened and reduced. Reduction maintained with forceps and external fixator applied either on the lateral or the anterior aspect of femur and tibia depending on the site of fracture and the soft tissue injury. The fractures are stabilized with at least 3 shanz screws proximal and 3 shanz screws distal to the fracture site and the stability ensured. In case of knee spanning external fixator the two fixators in the tibia and femur are connected by a tube to tube clamp. The wound is either closed if it’s a clean cut injury or non-contaminated or left open in case of contaminated injuries and grade IIIB fractures. These are later treated with either split skin grafts or muscle flaps once the wound is fit. Pin tract dressing done.

INSTRUMENTS AND IMPLANTS FOR EXTERNAL FIXATION

POST OPERATIVE MANAGEMENT

Post operatively analgesics were given in the form of intramuscular injections.

Intravenous antibiotics were given for 3 days post operatively for all closed fractures. Switch over to oral antibiotics was done on the 4th post-operative day, after check dressing and drain removal. Antibiotics were given according to the status of the wound in case of compound fractures. Skin sutures were removed on 12^{th} post-operative day.

Physiotherapy following fixation, early range of motion exercises were instituted depending on the consciousness level, hemodynamic condition, pain status and associated injuries.

For patients with poor Glasgow coma score passive range of motion exercises to the ankle and toe and calf muscle squeezing was done to prevent deep venous thrombosis. Chest physiotherapy was given to prevent the respiratory complications.

For conscious and hemodynamically stable patients active range of motion exercises was started to the ankle and toe on first post-operative day. Isometric quadriceps and isometric gluteal contraction exercises were given.

To prevent respiratory complications breathing exercises were given.

The patient was mobilized with non-weight bearing walking with the help of a walker. Partial weight bearing was started at 6 weeks once the x-rays shows sufficient callus at the fracture site.

Further weight bearing was instituted depending on the evidence of unions as visualized on radiographs. All patients were followed up, monthly for initial 4 months, thereafter 3 monthly for clinical and radiological evaluation of union status, knee range of motion and other complications.

Assessment of functional recovery of the patient was done using Karlstrom Olerud criteria[25] after minimum period of 4 months after injury.

KARLSTROM AND OLERUD CRITERIA

For Functional recovery of patient with floating knee injury

Criteria	Excellent	Good	Acceptable	Poor
Subjective Symptoms of thigh or leg	0	Intermittent Slight Symptoms	More Severe Symptoms impairing function	Considerable functional impairment pain at rest.
Subjective symptoms from knee or ankle joints	0	Intermittent Slight symptoms	More Severe Symptoms impairing function	Considerable functional impairment pain at rest.
Walking ability	Unimpaired	Intermittent Slight symptoms	Walking distance restricted	Uses cane, crutch or stick
Work & Sports	Same as before injury	Give up some sports. Work same as before injury.	Change to less strenuous work	Permanent disability
Angular or rotational deformity or both	0	$<10^{O}$	$10^{O} – 20^{O}$	$> 20^{O}$
Shortening	0	< 1 cm	1- 3 cm	> 3 cm
Restricted Joint movements Hip Knee Ankle	 0 0 0	 $<20^{O}$ $<20^{O}$ $<20^{O}$	 $20^{O} – 40^{O}$ $20^{O} – 40^{O}$ $20^{O} - 40^{O}$	 $>40^{O}$ $>40^{O}$ $>40^{O}$

OBSERVATIONS

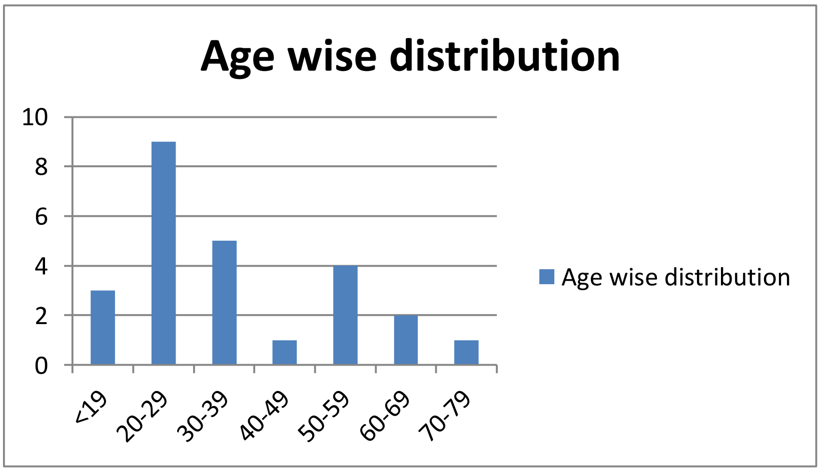
The present study includes 25 cases of ipsilateral fracture femur and tibia, treated in the Department of Orthopedics at Coimbatore medical college hospital, Coimbatore. The Patients were followed up for a minimum period of 4 months and a maximum of 20 months. The following observations were made in the present study.

DEMOGRAPHIC CHARACTERISTICS

1. Age wise Distribution

The youngest patient was 16 years old and oldest was 71 years.

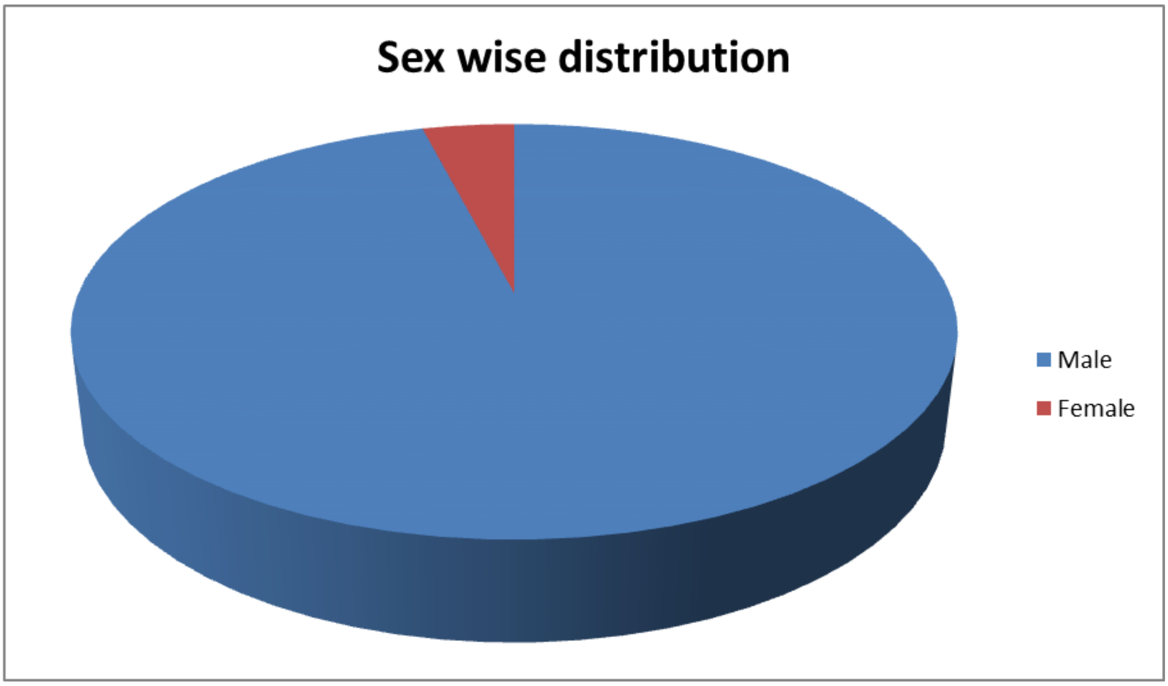
Age in Years	No. of Cases	Percentage
<19	3	12%
20-29	9	36%
30-39	5	20%
40-49	1	4%
50-59	4	16%
60-69	2	8%
70-79	1	4%



2. Sex wise distribution

Majority of the patients were males 96% (24 patients) and 4% (1 patient) patients were females.

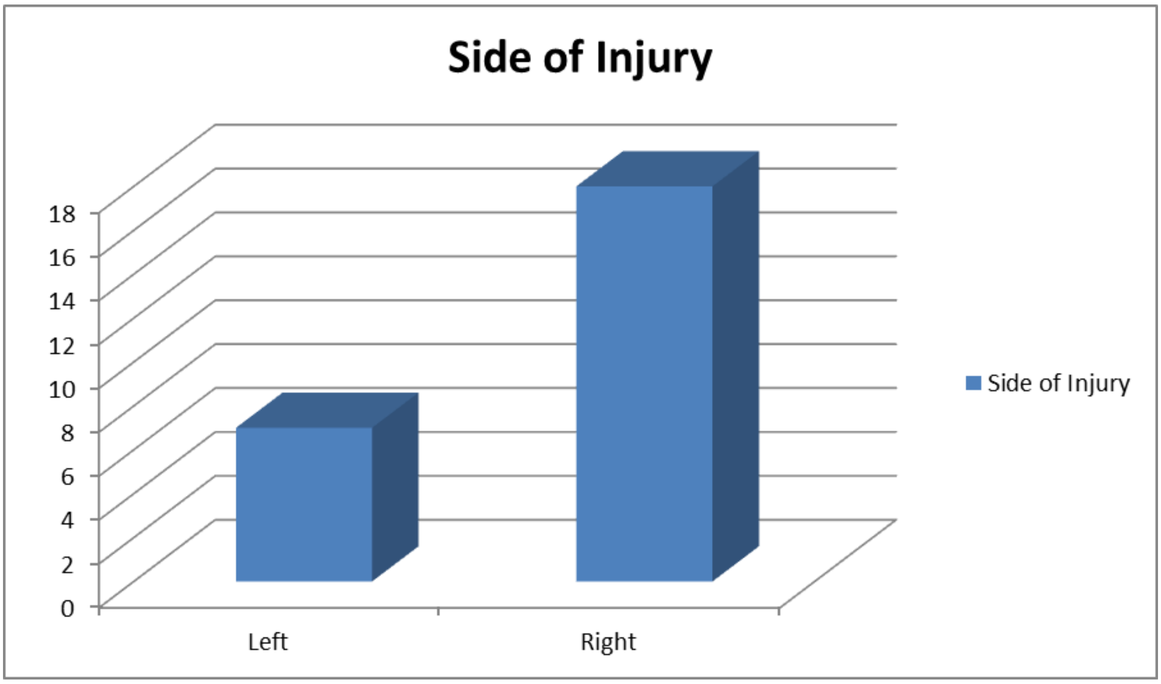
Sex	No. of Cases	Percentage (%)
Male	24	96%
Female	1	4%



3. Side of injury

Right side was involved in 18 patients (72%) in our study whereas only 7(28%) patients had left side injury.

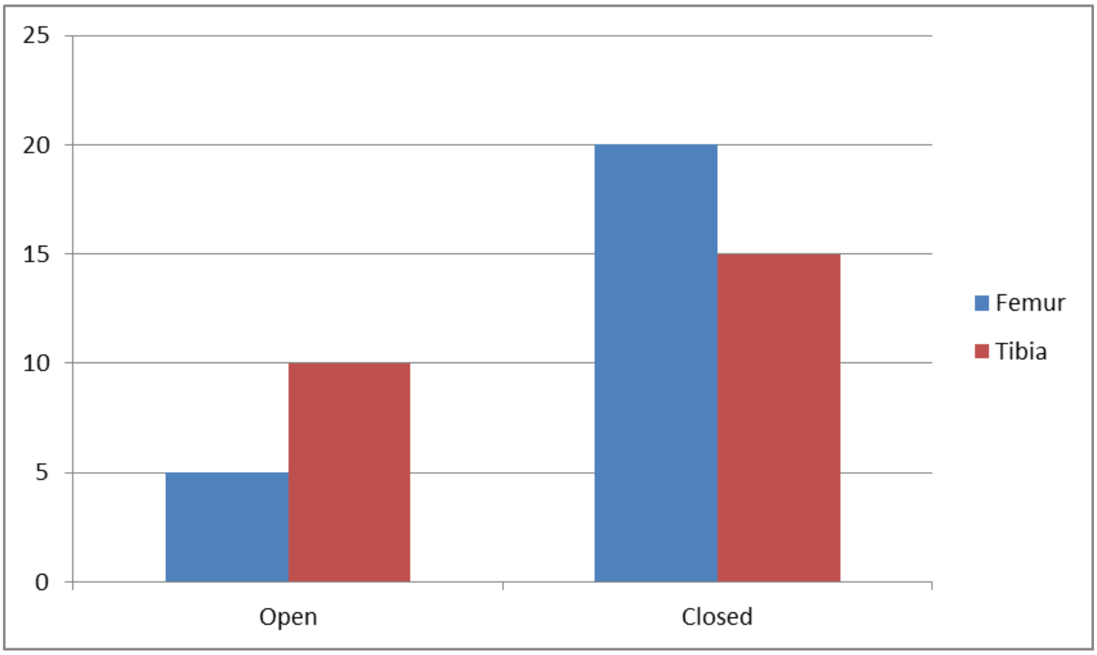
Side Affected	**No. of Cases**	**Percentage**
Right	18	72%
Left	7	28%



4. Closed and open Fractures

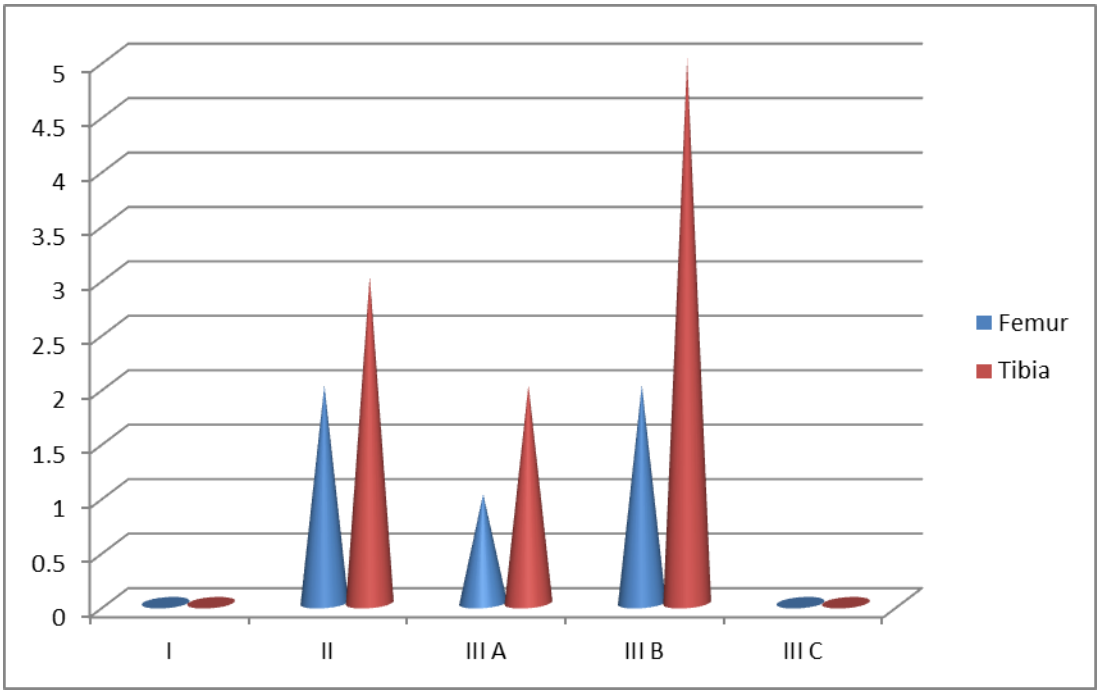
Femur fractures were closed in 20 patients and open in 5 patients whereas tibia fractures were closed in 15 patients and open in 10 patients. Both the fractures were closed in open in 5 patients.

	Closed	Percentage	Open	Percentage
Femur	20	80%	5	20%
Tibia	15	60%	10	40%
Both	15	60%	5	20%



5. Grading of Fracture

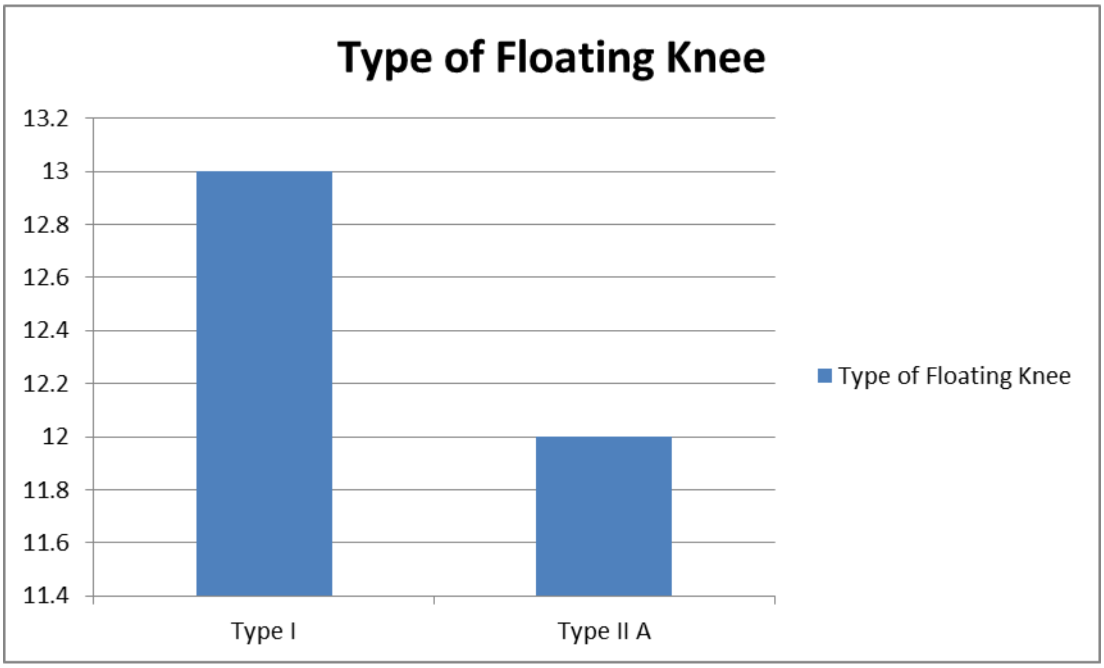
Grade	Femur	Tibia
I	0	0
II	2	3
IIIA	1	2
IIIB	2	5
IIIC	0	0
Total	5	10



6. **Type of Floating Knee**

13 out of total 25 patients were having extension of either femoral or tibial or both fractures into knee joint and the rest 12 patients were purely diaphyseal fractures.

Type of Floating Knee	
Type I	**Type II**
13	12
52%	48%



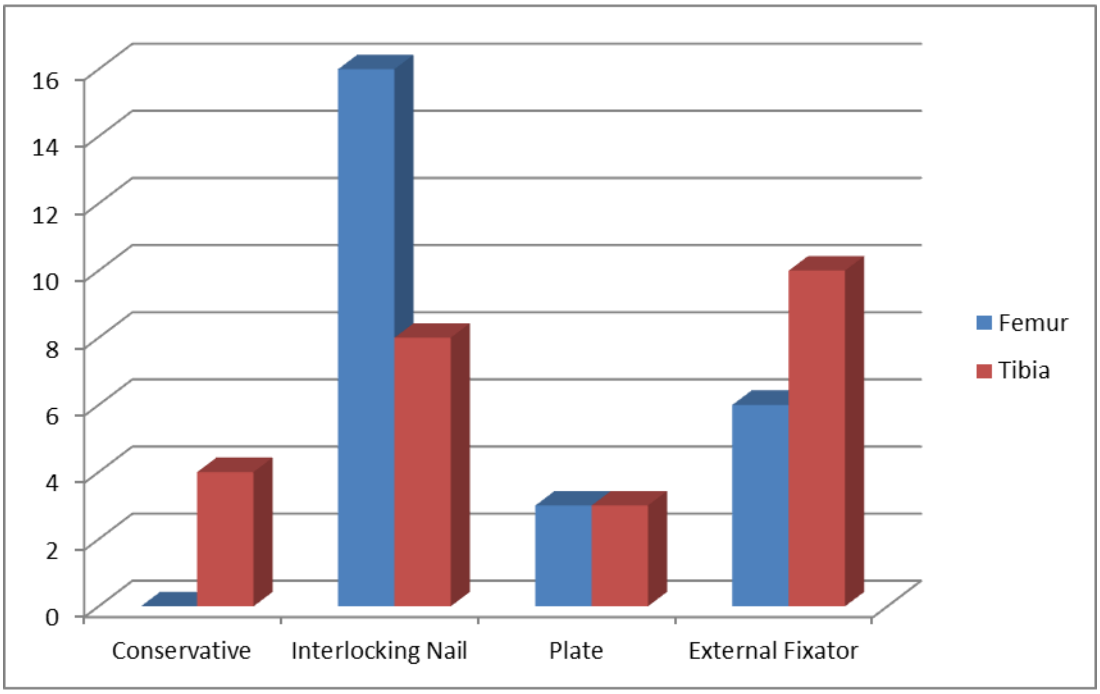
7. **Mode of Injury**

All 25 patients suffered injury because of road traffic accidents.

8. Treatment Modality

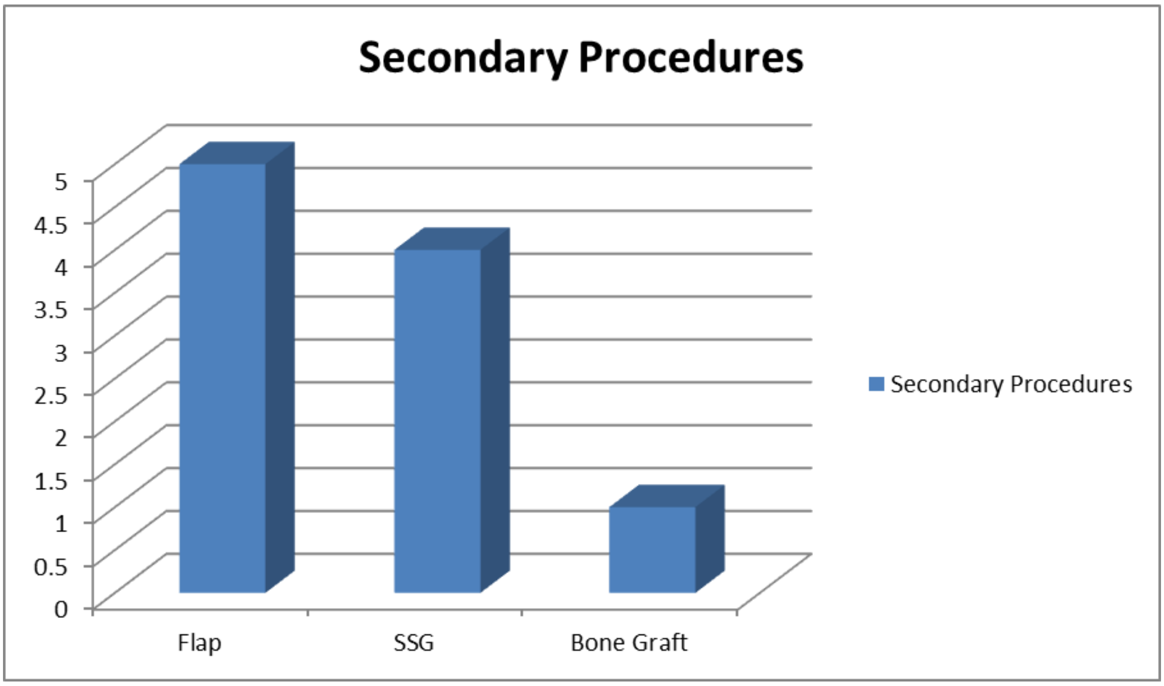
Intramedullary nail fixation was done in more number of patients in femur and external fixator in fracture tibia as compared to other modalities. Various modalities used are as follows

Treatment Modality	Femur	Tibia
Conservative	0	4
Intramedullary nailing	16	8
Plating	3	3
External fixator	6	10



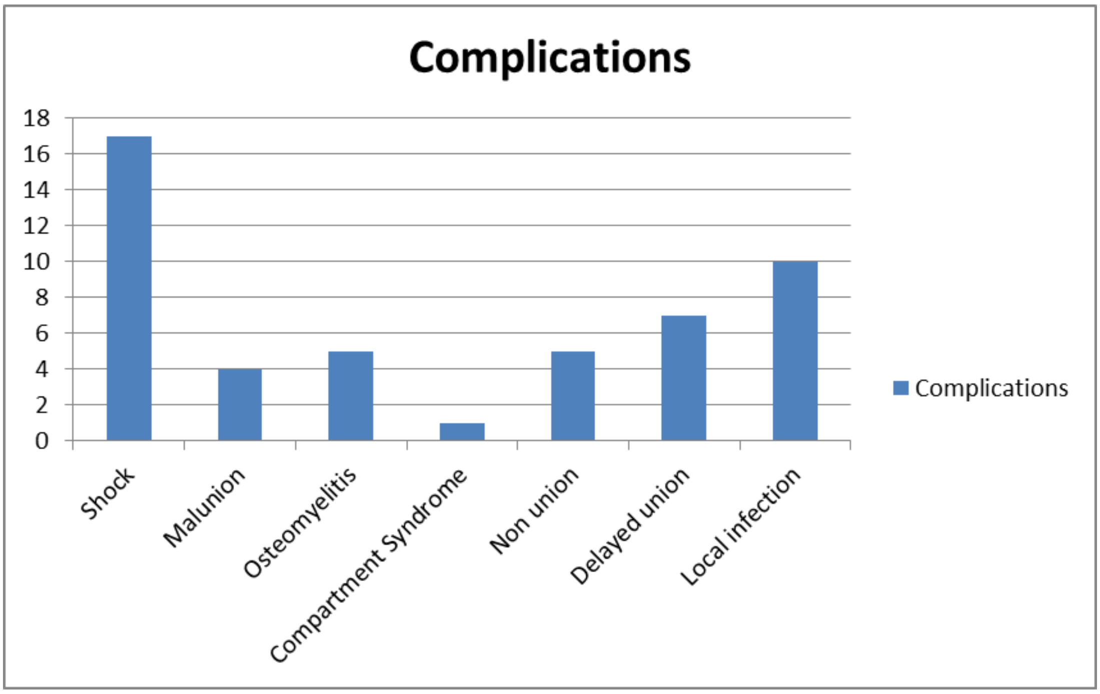
9. Secondary Procedures required

Procedure	Number
Skin Grafting	4
Flap	5
Bone Graft	1



10.Complications

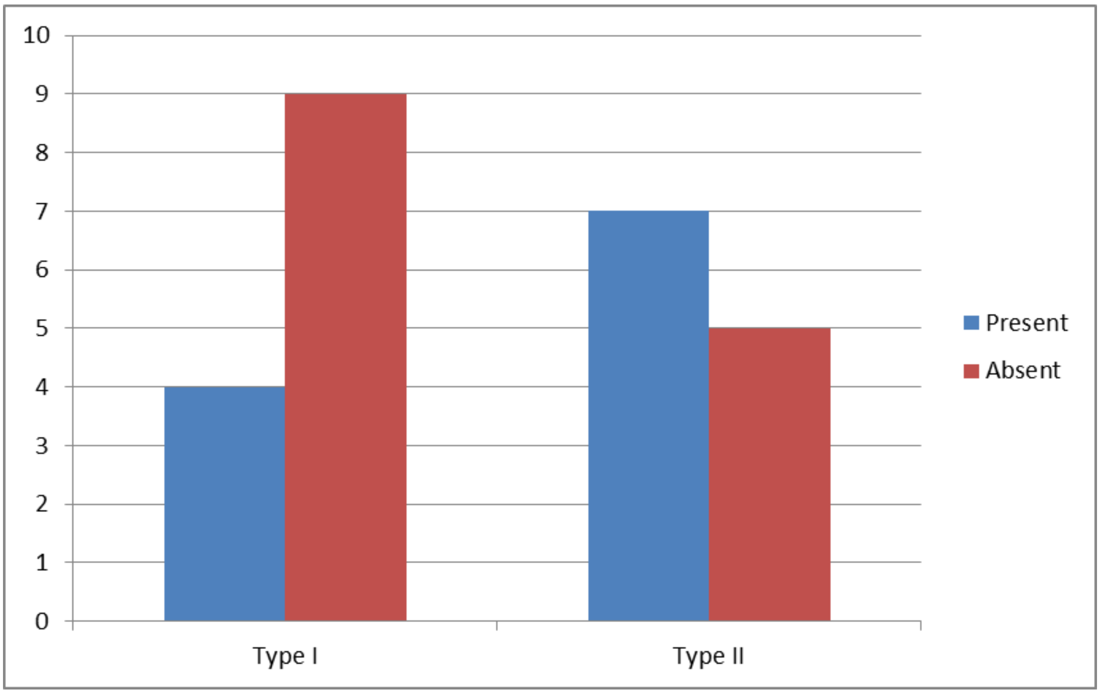
Sl.No	Complication		No.	Percentage
1	Shock		17	68%
2	Compartment Syndrome		1	4%
3	Mal Union	Femur	0	0%
		Tibia	4	16%
4	Delayed union	Femur	4	16%
		Tibia	3	12%
4	Non Union	Femur	0	0%
		Tibia	5	20%
5	Chronic osteomyelitis	Femur	1	4%
		Tibia	4	16%
6	Knee Stiffness		15	60%
7	Shortening > 3 cm		5	20%
8	Local infection	Femur	2	8%
		Tibia	8	32%



11.Knee Stiffness

Incidence of Knee Stiffness is 36% in Type IIA floating knee injuries as compared to 16% in Type I floating knee injuries.

Type of Floating Knee	Type I	Type II	Total
No. of Cases	13	12	25
Knee Stiffness	4	7	11
Percentage (%)	30.76%	58.33%	44%
Average Flexion	0^{o}-120^{o}	0^{o}-70^{O}	0^{o}-108^{O}



12.Shortening

In our study 5 out of 25 cases developed more than 3 cm shortening. All 5 cases were due to severe comminution and soft tissue injury. These were managed with heal and sole raised footwear.

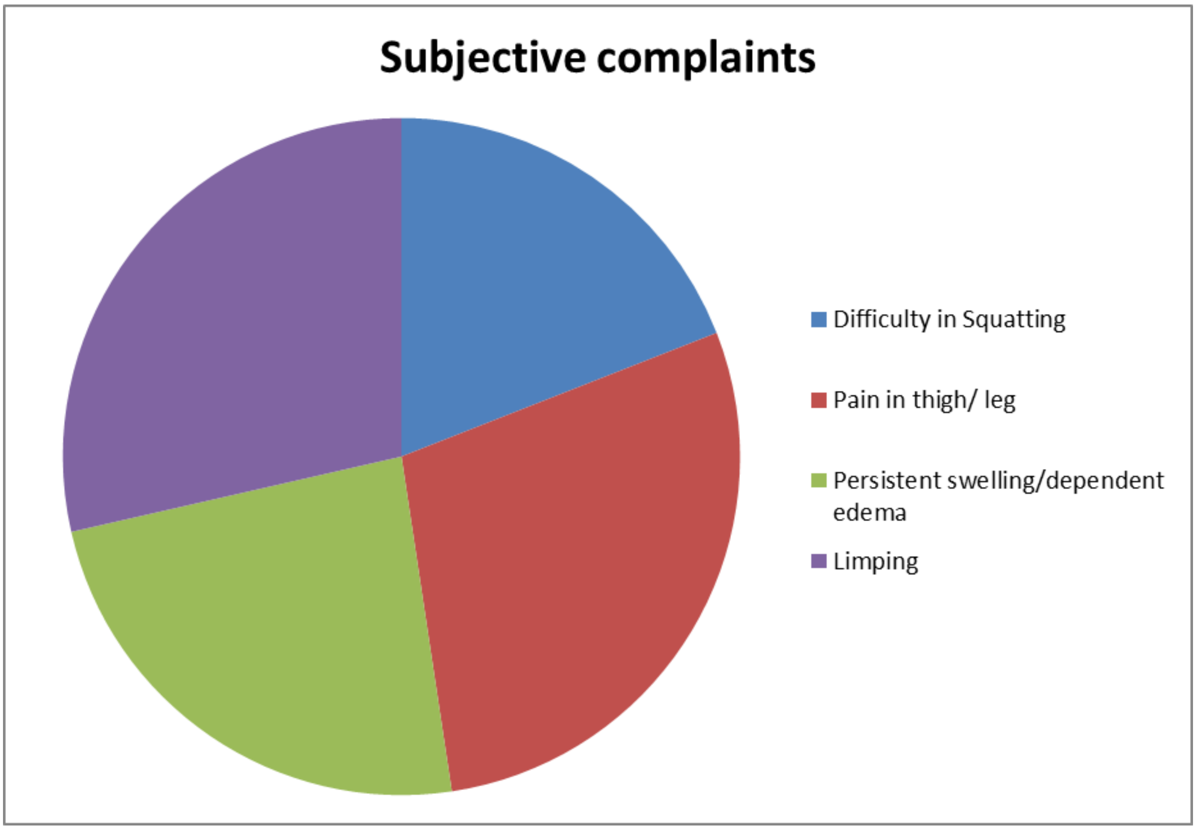
13.Subjective complaints

i) Limping – 12 cases

ii) Pain in thigh / leg – 12 cases

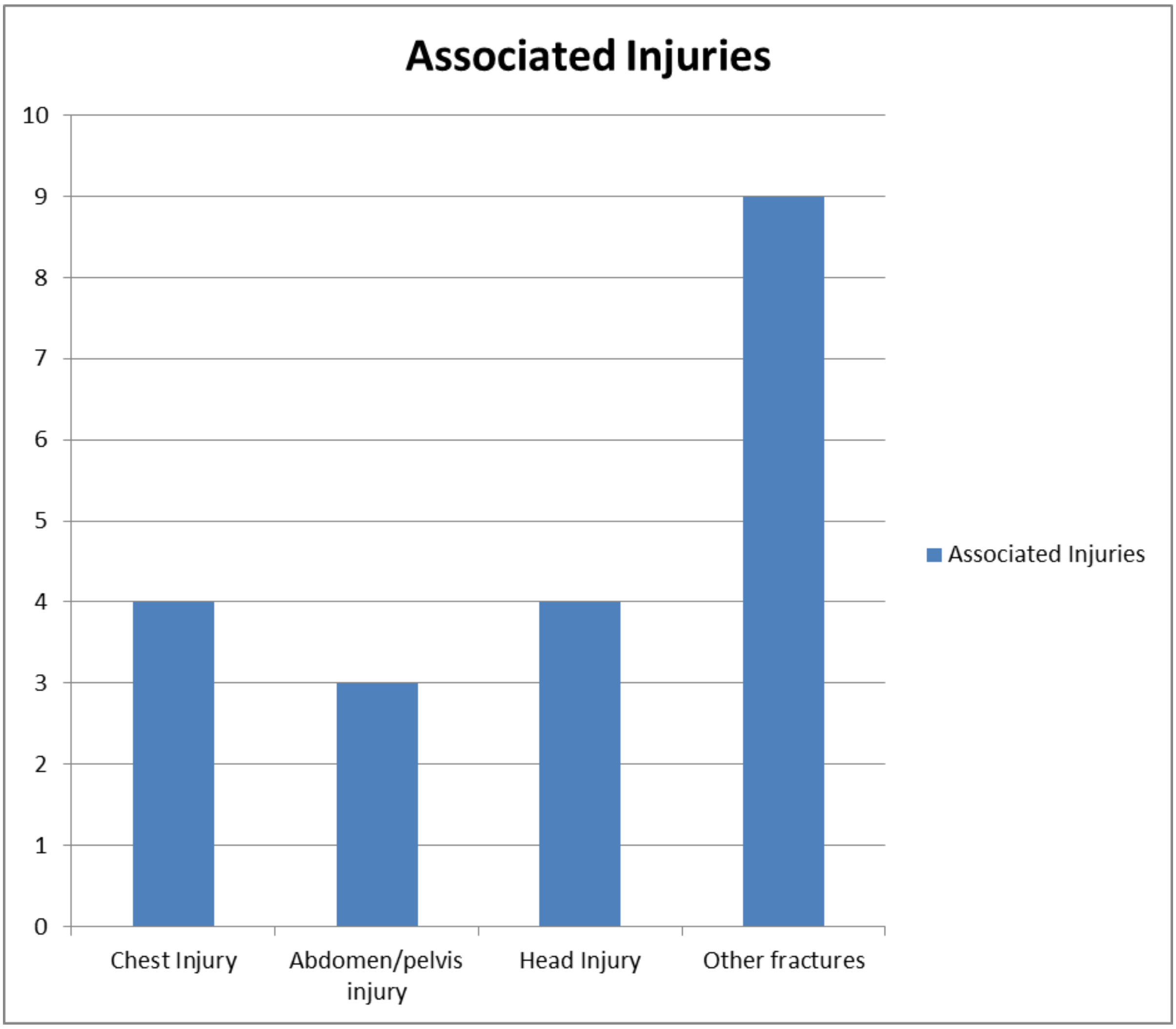
iii) Persistent swelling / dependent edema – 10 cases

iv) Difficulty in squatting – 8 cases



14. Associated Injuries

Associated Injury	**No. of Cases**	**Percentage%**
Head Injury	4	16%
Abdomen + Pelvis Injury	3	12%
Chest Injuries	4	16%
Other Fractures	9	36%



15. Karlstrom and Olerud Criteria-For Functional recovery of patients with floating knee injury in our study

Criteria	Excellent	Good	Acceptable	Poor
Subjective Symptoms of thigh or leg	(9)	(7)	(4)	(5)
Subjective symptoms from knee or ankle joints	(10)	(6)	(4)	(5)
Walking ability	(10)	(10)	(2)	(3)
Work & Sports	(10)	(6)	(6)	(3)
Angular or rotational deformity or both	(11)	(8)	(2)	(4)
Shortening	(13)	(5)	(2)	(5)
Restricted Joint movements				
Hip	(16)	(5)	(4)	(0)
Knee	(10)	(4)	(4)	(7)
Ankle	(20)	(2)	(3)	(0)

RESULTS

The present study included 25 cases of floating knee injuries admitted in Coimbatore medical college hospital, Coimbatore. The main aim of treatment of both femur and tibia fractures in floating knee injuries is to make the patient ambulatory and start rehabilitation as early as possible so as to reduce hospital stay, morbidity due to complications such as delayed union, nonunion or knee stiffness. Majority of patients were male (96%) from 20 to 40 years of age involving the right side in 18 out of 25 (72%) floating knee injuries following the high velocity road traffic accident. Out of 25 cases of floating knee injuries only 1 patient was female (4%) and in only 7 cases (28%) left side was involved. The results of our study are as follows:

Union of femoral fractures

In our study, 16 femur fractures were treated with intra medullary interlocking nail, 6 cases with External fixator and 3 cases with plating/DCS.

Four cases of femur showed delayed union. These cases of delayed union were badly comminuted open fractures.

Union of Tibial fractures

In our study, 8 tibial fractures were treated with intramedullary interlocking nail, 10 cases with External fixator, 3 cases with buttress plating and the rest treated conservatively.

In our study 17 fractures united in average 4 months period (Range 3-5 months) and three cases showed delayed union. Five tibial fractures went into nonunion. One fracture required bone grafting whereas the rest went into union following dynamization.

Winston M.E[47] recommended conservative treatment for floating knee injuries to be safe method producing acceptable results without dangers of infection, which is present with internal fixation. In our study four undisplaced tibial fractures were treated conservatively with above knee cast. There was local infection in 8 cases of tibial fractures out of 25 and 2 infections associated with femoral fracture. Only 4 fracture tibia and 1 fracture femur developed chronic osteomyelitis which were open Grade IIIB according to Gustilo - Anderson classification.

Yue et al., Chirchill R.S.[49] in a comparative study of operative and non-operative treatment of ipsilateral fractures of femur and tibia concluded that operative stabilization was associated with less leg length discrepancy, angular malunion and secondary procedures from conservative treatment.

In comparison to study of Boscher, Fouque, Le Nay of 26 cases of floating knee treated by internal fixation 13 healed without complication and other 6 healed after complication had been treated; where as in our study of 25 cases 4 cases of femur fracture showed delayed union, 3 cases of tibial fractures had delayed union and 5 tibial fracture developed nonunion which healed after secondary surgeries. So results in our study are consistent with study conducted by Boscher, Fouque, Le Nay.

Hospitalization Period:

In our study average hospitalization period was 40 days. When both the fractures were closed and treated with early internal fixation, total hospital stay of patient was 2-3 weeks.

Recently aggressive operative treatment has been suggested for floating knee injuries by several investigators. In these reports they emphasized that the operative treatment has resulted in less hospitalization period, fewer complications and better functional outcome than does non-operative treatment.

In a study by Anastopopulous .G[6] 32 cases of floating knee were treated. The tibial fracture treated by unilateral external fixator and femoral fracture was fixed with closed intramedullary nailing, the time of hospitalization ranged from 12 to 105 days (mean 30 days) ; where as in our study of 25 cases of floating knee all femur fractures were treated surgically, 21 out of 25 tibia fractures are treated surgically and 4 fractures conservatively, the time of hospitalization ranged from 30 to 50 days (mean 40 days).

Knee Joint Motion:

In our study fifteen patients (60%) achieved excellent to acceptable knee range of motion of 0-100^{O}. Knee stiffness, that is loss of knee flexion of more than 30 degrees developed in 7 cases out of the total 12 Mcbryde and Blake Type IIA floating Knee cases, whereas 4 patients out of 13 McBryde and Blake Type I floating knee developed knee stiffness.

Compound fractures of femur and tibia which developed complication such as delayed union, nonunion or osteomyelitis lead to knee stiffness even when extra articular. Thus intra articular extension of either one or both fractures into knee joint was associated with markedly higher incidence of knee stiffness. In Type I floating knee injuries treated with early internal fixation and vigorous early physiotherapy showed better results than cases treated with delayed fixation and prolonged immobilization.

Functional Recovery

By using Karlstrom & Olerud criteria the functional outcome in our study was excellent in 10 (40%) patients; good in 5 (20%) patients; acceptable in 3 (12%) patients and poor in 7 (28%) patients.

In comparison to Karlstrom G., Olerud S.[25] study of 32 cases in which overall excellent to good results were obtained in 86% , our study shows 60% of overall excellent to good results. Whereas study by Veith et al[45] had 72% excellent to good and Anastopoulas et al[6] had 81%

overall excellent to good results. These results are much better than conservative series of Fraser et al[14] which shows 29% excellent to good results.

Results of Type IIA fractures are poor than that of fractures without involvement of knee joint. Rethnam V.[1] concluded that the prognostic fractures in floating knee injuries include the associated injuries and the type of fracture whether it is open, intra-articular or comminuted. In comparison to results of type II floating knee injuries, 24% excellent to good in series by Adanson et al[5] our results are excellent to good in 25% cases; whereas Hung et al[21] had 23.8% excellent to good results in their study.

Yokoyama et al[48] concluded that involvement of knee joint, the severity grade of soft tissue injury represent significant risk factor of poor outcome of floating knee injuries.

In our study 64% of patients returned to their pre injury functional status with or without some modification in the work pattern. 12% patients never returned to their pre injury functional status due to permanent disability. Thus floating knee injuries result in significant amount of morbidity and permanent disability.

Comparative Results of Floating Knee Injuries

Series	Excellent – Good	Acceptable Poor
Karlstrom Olerud et al[25]	86%	14%
Fraser et al[14]	29%	71%
Veith et al[45]	72%	28%
Anastopoulas et al[6]	81%	19%
Our Series	60%	40%

Comparative Results of Type II Floating Knee Injuries

Series	Excellent – Good	Acceptable Poor
Adanson et al[5]	24%	76%
Hung et al[21]	23.8%	76.2%
Our Series	25%	75%

DISCUSSION

Due to increase in motor vehicle accidents, patients with multiple system involvements are increasing in number. During the treatment of such patients, there are two major considerations. First is a systemic injury with body response to injury complicating the situation and second is problem associated with concomitant fractures.

In our study 28 cases of floating knee were treated in Coimbatore medical college hospital, Coimbatore. There were 3 deaths out of 28 cases of floating knee injury (10.7%). Most of the patients were between 20-40 years age group indicating that it is an injury occurring commonly in young adults.

The floating knee injuries were treated aggressively with surgical methods by Karlstrom and Olerud in 1977[25].

Aggressive operative treatment has been suggested for floating knee injuries by several investigators. The operative treatment has resulted in less hospitalization, less systemic complications and better functional outcome than non-operative treatment.

In the literature, the average length of hospitalization in most operative series was from 30-36 days. Karlstrom and olerud[25] reported the period of hospitalization was 11.5 weeks on an average when both fractures were treated surgically. Gregory et al reported hospitalization of 17 days. In our study average hospitalization period was 40 days.

Omer et al[33] reported 31% incidence of infection in non-operatively treated patients. Fraser et al[14] reported higher infection rate in those treated with stabilization of both the fractures surgically than those treated non-operatively (20% Vs. 8%). Veith et al[45] reported only 5% infection rate when any one of the fracture was surgically stabilized. Mc Andrew[30] and Gregory et al[16] respectively reported deep infection in 22% of tibial fractures and 11% in femur fractures. In our series deep infection rate was 16% in tibial fractures and 4% in femur fracture and is comparable to previous studies.

Karlstrom and olerud[25] reported healing time of around 20 weeks whereas according to Adanson et al[5] it was 39 weeks for femur and 37.5 weeks for tibia. In our series average healing time was around 24 weeks for femur and 25 weeks for tibia which is comparable to previous studies.

By using Karlstrom and Olerud[25] criteria the functional outcome was excellent in 10 patients (40%), good in 5 patients (20%), acceptable in 3 patients (12%) and poor in 7 patients (28%). Thus excellent to good results were obtained in 60% patients as compared to 86% in karlstrom and olerud[25] series, 72% in Veith[45] series and 81% in Anastropopulas[6] series. These results are better when compared to non-operative treatment according to Fraser et al (29%)[14].

SUMMARY

In our study, functional outcome was analyzed as a prospective study in 25 cases of floating knee injuries in Coimbatore Medical college hospital, Coimbatore.

In our study the following results were obtained:

1. Males are affected in 24 out of 25 patients (96%).
2. Right lower limb was involved in 18 out of 25 patients (72%).
3. Majority of the patients were of young age group between 16-40 years (68%).
4. Thirteen out of 25 patients (52%) had type I floating knee injury and 12 out of 25(48%) had type II floating knee injury.
5. In most of the cases (72%) surgery was performed within 1 week of trauma.

Our aim was early stabilization of the fractures to achieve better functional outcome. Patients were followed up on monthly basis for initial 4 months, there after 3 monthly for clinical and radiological evaluation of union status, knee range of motion and other complications.

Assessment of functional outcome was done using Karlstrom and Olerud criteria after a minimum period of 4 months from the date of injury.

In our study 58% patients (7 out of 12) with Type IIA floating knee injury had knee stiffness as compared to 30% patients (4 out of 13) with Type I floating knee injury.

In our study average range of motion of knee joint was 0^o-120^o in Type 1 floating knee and 0^o-70^o in Type IIA floating knee.

In our study 5 out of 25 patients (20%) developed more than 3 centimeter shortening due to severe comminution and soft tissue injury. These were managed with heel and sole raised footwear.

CONCLUSION

From our study, we conclude:

1. Aggressive wound debridement with early stabilization provide good functional outcome in treatment of floating knee injury.

2. Internal fixation of fractures permits early mobilization of the knee joint with good functional outcome.

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ILLUSTRATIVE CASES

1. A 28 year old male patient met with road traffic accident, 2 wheeler vs. 4 wheeler and sustained injury to right lower limb.

Pre-op X-rays

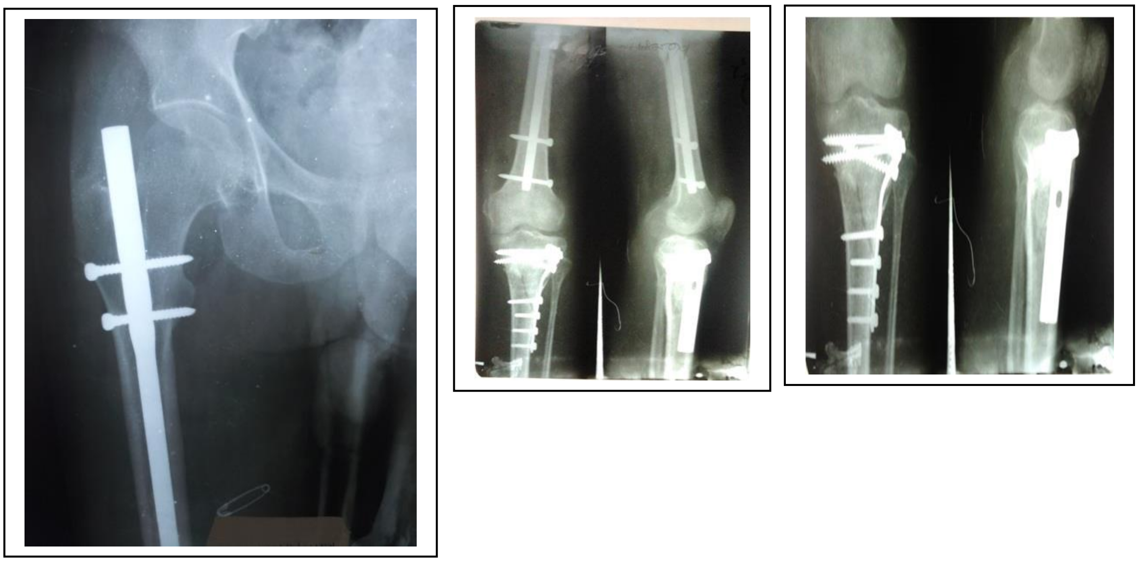
Immediate Post-op X-rays

12 months follow up

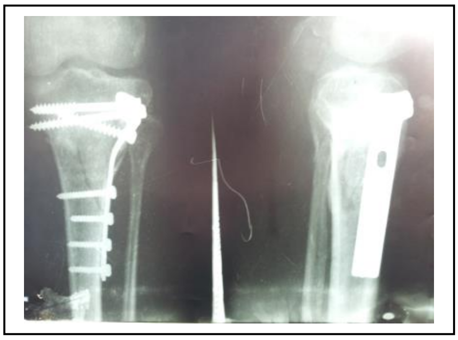
2. A 35 year old male patient met with road traffic accident, hit by a car while walking in the road and sustained injury to right lower limb.

Pre-op X-rays

Immediate Post-op X-rays



12 months follow up

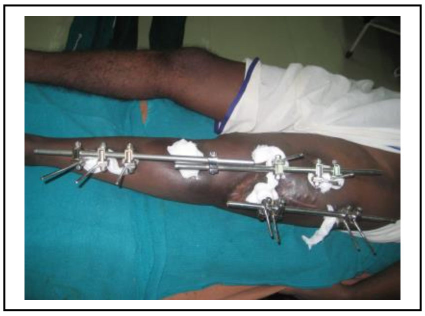


3. A 32 year old male patient came with history of RTA, hit by a tractor sustained compound injury to left lower limb. Patient had history of childhood hip disease with limb shortening.

Pre-op X-rays

Immediate Post-op X-rays

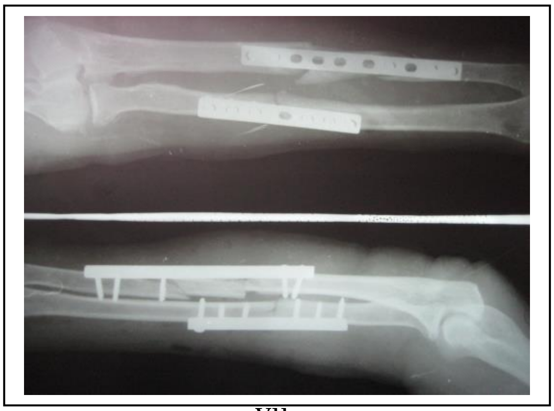
20 months follow up



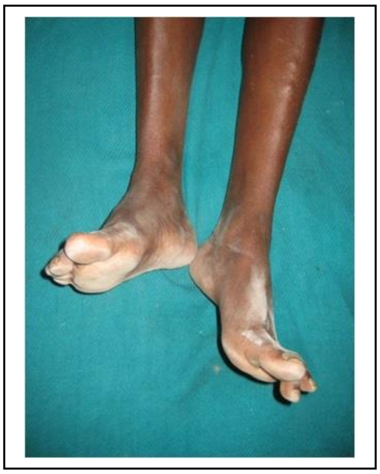
4. A 52 year old male patient met with road traffic accident, 2 wheeler vs. 4 wheeler and sustained injury to right lower limb and right forearm.

Pre-op X-rays

Immediate Post-op X-rays



10 months follow up



5. A 34 year old male patient met with road traffic accident, 2 wheeler vs. 4 wheeler and sustained compound grade IIIB injury to right lower limb

Pre-op X-rays


Immediate Post –op




5 months follow up

6. A 34 year old male patient met with road traffic accident, 2 wheeler vs. 4 wheeler and sustained injury to right lower limb.

Pre-op X-rays



Immediate Post-op




4 months follow up

PROFORMA CASE NUMBER:

Name :

Age :

Sex :

IP No. :

Address :

Telephone No. :

Occupation :

HISTORY

Complaints :

Mode of Injury :

Date of Injury :

Medical History :

EXAMINATION

General condition (Shock Management) :

Associated Injuries :

Pulse:
BP:
Temp:
Respiratory Rate:

LOCAL SURVEY

Limb Injured (Rt / Lt) :

Extension into Knee Joint :

Simple / Compound :

Distal Neurovascular Complication :

Local Skin Condition :

TRAUMA SCORE

Glasgow Coma Scale :

RADIOGRAPH

Classification (Blake and Mcbryde) :

EMERGENCY TREATMENT

Shock :

Debridement :

External Fixator :

Need for Soft Tissue Procedure :

OPERATIVE DETAILS

Injury Surgery Interval :

Anesthesia :

Sequence of Surgery :

Treatment Modality : Femur :

Tibia :

Intraoperative complications (if any) :

POST OPERATIEV MANAGEMENT

Duration of Immobilization :

FOLLOW UP

Subjective Complaints :

Range of Knee, Hip and :

Ankle Movements

Ambulatory Status :

Radiological Signs of Union :

Functional Status :

COMPLICATIONS

Mal Union :

Delayed Union :

Non-Union :

Knee Stiffness :

Shortening :

Infection :

SECONDARY PROCEDURES

Skin Grafting :

Local Flap :

Bone grafting :

MASTER CHART

Name	Age	Sex	IP No	Side	Fe-CL/OP	T-CL/OP	Gr Of OP #	Type	MOI	Fe -tmt	T-tmt	SP	Complications	KS	S	Associated injury
Palanisamy	52	M	6178	R	CL	CL		I	RTA	IL nail	IL nail		Shock	A	A	# BB R forearm
Kariyappa	35	M	27891	R	CL	CL		IIA	RTA	IL nail	Plate		Shock	P	A	# patella right
Marimuthu	28	M	57891	R	CL	CL		IIA	RTA	Plate	Plate		Shock,Mal tibia	A	A	CI
Muthukumar	28	M	63236	R	CL	CL		I	RTA	IL nail	IL nail		Shock,NU tibia	A	A	HI
Viji	32	M	67802	L	OP	OP	Fe & T-II	IIA	RTA	Ex fix	Ex fix	SSG	Shock,Chr Ost,DU femur	P	A	None
Ramesh	23	M	60039	R	OP	OP	Fe & T-IIIB	IIA	RTA	Ex fix	Ex fix	Flap	Shock, DU tibia	P	P	None
Karthikeyan	32	M	32156	L	OP	OP	Fe & T-IIIB	IIA	RTA	Ex fix	Ex fix	Flap	Chr Ost femur ,NU tibia,DUfemur	P	P	None
Moorthy	62	M	70684	R	CL	CL		IIA	RTA	IL nail	Cons		Mal tibia	P	P	CI
Antony Victor	28	M	62289	R	CL	CL		I	RTA	IL nail	IL nail		Shock,DU femur	A	A	None
Ramasamy	71	M	49694	R	CL	OP	T-IIIB	IIA	RTA	Ex fix	Ex fix	Flap	Shock,Chr Ost tibia	P	A	None
Krishnamoorthy	37	M	50644	R	CL	CL		I	RTA	IL nail	IL nail		Shock	A	A	# shaft of L femur
Karuppasamy	27	M	43876	R	CL	CL		I	RTA	IL nail	Cons		Shock,Mal tibia	P	A	CI, HI
Rajesh	25	M	69042	L	CL	CL		I	RTA	IL nail	IL nail		Shock	A	A	None
Shanmugam	55	M	54486	L	CL	CL		I	RTA	IL nail	IL nail		Shock,DU tibia	A	A	AI
Lokesh	16	M	63295	R	CL	CL		I	RTA	Plate	Cons		Shock,DU femur	P	A	None
Vinoth	25	M	71754	R	CL	OP	T-IIIB	I	RTA	IL nail	Ex fix	SSG	Chr Ost tibia	P	A	# R Acetabulum
Shanmugam	53	M	62282	R	OP	OP	Fe II & T-IIIA	IIA	RTA	Ex fix	Ex fix	Flap	Chr Ost tibia	P	A	# Rmetatarsals
Nithyanandan	18	M	61589	R	CL	CL		I	RTA	IL nail	IL nail		Shock,DU tibia	A	A	# L humerus
Rajasekar	17	M	371	L	CL	CL		IIA	RTA	IL nail	Plate		Shock	A	A	# R femur
Nagappan	61	M	63558	R	CL	CL		I	RTA	IL nail	IL nail		Shock,NU tibia	A	A	CI
Rangan	50	M	73024	R	CL	OP	T-II	I	RTA	IL nail	Ex fix	SSG	Chr Ost tibia	P	A	# L femur
Rathinam	40	F	61471	L	CL	CL		IIA	RTA	Plate	Cons		Shock, Mal tibia	P	A	HI, AI
Giriyan	34	M	32361	R	OP	OP	Fe & T-IIIB	IIA	RTA	Ex fix	Ex fix	Flap, BG	NU tibia	P	A	HI
Senthil Kumar	24	M	51022	R	CL	OP	T-IIIA	I	RTA	IL nail	Ex fix	SSG	NU tibia	P	A	# of R 5th MC
Ramamoorthy	23	M	51045	R	CL	OP	T-II	IIA	RTA	IL nail	Ex fix		CS	P	A	None

ABBREVIATIONS:#-Fracture, AI-Abdominal injury,B.B.-Both Bones, BG -Bone grafting, Chr Ost-Chronic Osteomyelitis, CI - Chest injury, CL-Closed, Cons-Conservative, CS - Compartment syndrome, DU -Delayed union, Ex fix - External fixator, F-Female, Fe – Femur, GCS - Glascow coma scale, Gr- Grading, HI - Head injury, IL Nail- Interlocking nail, IP-In patient, KS -Knee stiffness, L -Left, M-Male, Mal- Mal-union, MC- Metacarpal, MOI- Mechanism of injury,No – Number, NU - Nonunion, OP-Open, R-Right, RTA -Road traffic accident, S – Shortening, SP - Secondary procedures, SSG-Split skin graft, T – Tibia, tmt - Treatment

“Analysis of functional outcome in

Floating knee injury”

ABSTRACT

Background:

The term floating knee is defined as simultaneous ipsilateral fracture of femur and tibia that disconnect the knee from the rest of the limb. It includes both intra-articular and extra-articular fractures. Surgical stabilization of both the femur and tibia fractures, early rehabilitation of the patient produces best clinical outcome. The aim of the study is to analyze the functional outcome in floating knee injury in Coimbatore Medical College Hospital, Coimbatore.

The objective is to study the various modalities of management and complications associated with floating knee injuries.

Materials and methods:

The study was done in the department of Orthopedics at Coimbatore medical college hospital, Coimbatore from June 2010 to December 2012 which includes 25 patients with 25 floating knee injuries. This is a prospective study.

Results:

Assessment of functional outcome was done using Karlstrom and Olerud criteria after a minimum period of 4 months from the date of injury. The results obtained in our study are comparable to the previous studies with respect to knee stiffness, shortening, hospital stay in floating knee injury patients.

Conclusion:

Aggressive wound debridement with early stabilization provide good functional outcome in treatment of floating knee injury. Internal fixation of fractures permits early mobilization of the knee joint with good functional outcome.

Keywords:

floating knee, femur, tibia, debridement